VOL.
1
1958

Rheology Abstracts

A Survey of World Literature

Volume I

[redacted]

[redacted] 1958

London New York
Paris Los Angeles

Published by
PERGAMON PRESS LIMITED
for the
BRITISH SOCIETY OF RHEOLOGY

RHEOLOGY ABSTRACTS

Published by Pergamon Press Limited for the
British Society of Rheology

Hon. Editor : J. H. C. VERNON, B.Sc., Ph.D.

VOL.
1
195

THE BRITISH SOCIETY OF RHEOLOGY

Officers and Committee for 1957/58

President : Professor E. G. RICHARDSON, B.A., Ph.D., D.Sc., F.Inst.P.

Hon. Secretary : N. WCOKEY, B.Sc., A.Inst.P.

Hon. Treasurer : D. W. JOPLING, B.Sc., A.R.I.C.

Hon. Editors : J. H. C. VERNON, B.Sc., Ph.D.
E. W. J. MARDLES, D.Sc., F.R.I.C.

Members of Committee :
H. Ll. D. PUGH
A. S. LODGE, M.A., D.Phil.
J. F. HUTTON, B.Sc., A.Inst.P.
C. C. MILL, M.Sc., A.Inst.P.
A. JOBLING, A.R.C.S., Ph.D., F.R.I.C.
M. F. CULPIN, Ph.D., A.Inst.P.
G. H. TATTERSALL, M.Sc., A.Inst.P.

Publishing Offices : 4 & 5 Fitzroy Square, London, W.1 (EUS 4455)

Subscription : £2 per volume of 4 issues
Payment must be made in advance
Copyright © 1958 British Society of Rheology

PERGAMON PRESS LTD.
4 & 5 Fitzroy Square, London, W.1
122 East 55th Street, New York 22, N.Y.

RHEOLOGY ABSTRACTS

Author Index to Volume I

A

Ackroyd, G. C., 358
Adcock, D. S., 195
Adkins, J. E., 459
Aggarwal, S. L., 87
Aikhodzhaev, V. I., 550
Akutin, M. S., 286
Albright, L. F., 154, 317
Alekseenko, V. I., 289, 546
Alexander, W. J., 94
Allsopp, H. L., 54a
Alperovich, I. A., 440
Ames, W. F., 538
Anderson, A. A., 413, 534
Anderson, R. A., 50
Andrews, R. D., 89
Andrussow, L., 190
Anon, 143, 149, 200, 327, 360, 419, 565, 582
Antonevich, N. K., 305
Arnim, E. von, 79
Assonova, T. V., 543a
Atkins, J. T., 271
Austin, J. M., 102
Azaron, K. P., 584

B

Baarli, J., 480
Baccaredda, M., 513
Bagley, E. B., 268
Baker, C. J., 218
Bakker, E. J., 485
Ballou, J. W., 486
Bao Sen-ke, 500
Barnes, R. S., 159
Bartenev, G. M., 237, 252
Bartok, W., 473
Bartusch, W., 574
Basu, S., 526
Bauer, W. H., 306
Beerbower, A., 168
Belashchenko, D. K., 499
Belcher, H. V., 516
Bell, J. F. W., 377
Benecke, J. H., 202
Beran, M. J., 156
Berezhnoi, A. I., 73
Berg, B. A., 465
Berge, J. W., 121
Berger, W., 202
Bernhard, H., 453
Berry, D. S., 187
Best, C. H., 75
Bhatnagar, H. L., 264
Bigelow, C. C., 426
Bikerman, J. J., 166, 184
Biot, M. A., 24
Bird, G. R., 371
Bishop, G. F. W., 335
Biswas, A. B., 264
Blackburn, W. S., 2
Blout, E. R., 371
Bodor, G., 279, 490
Boettner, R. C., 366
Bogautdinova, G. G., 388
Bogusz, W., 178
Bolliger, R., 523
Bonner, F. T., 351
Bossu, B., 492
Bouche, R. R., 209
Bowden, F. P., 227
Bradfield, G., 38
Brady Williamson, R., 107
Brodnyan, J. G., 91, 106
Broome, D. C., 300, 301, No. 4 p. 26
Brown, A. F. C., 230
Brown, A. M., 431
Brown, C. P., 256
Brown, E. H., 344
Brown, G. H., 325
Brown, H. L., 211
Brown, R. L., 553
Browne, M. T., No. 3, p. 24
Bruckner, R., 51
Brunton, J. H., 227
Buchdahl, R., 405
Budnikov, Pl. P., 440
Bueche, A. M., 77
Bueche, F., 18, 78
Bukowski, B., 241
Buks, Z. P., 326
Bull, T. H., 485
Burnett, H. C., 208
Burnett, J., 34, 222
Burns, W. G., 477
Burte, Harris M., 61
Busby, A. L., 314
Butta, E., 84, 513

C

Cabott, I. M., 268
Caldwell, E. F., 488
Calish, S. R., Jun., 161
Carroll, J. G., 161
Carter, H. D., 226
Carwile, N. L., 381
Cerf, R., 115, 265
Chandrasekhar, S., 461
Chang, T. S., 40
Chanin, W. G., 171
Charlesby, A., 79
Chatfield, H. W., 141
Chaudhury, P. R., 526
Checkland, P. B., 485
Chen-Jen-Yuan, 249
Chen Khun-I, 500
Cheng-Yung-Shih, 249
Chichester, C. O., 48
Chien Pao-Kung Yu Fu-Sen, 253
Child, W. C., Jun., 124
Ching-Wen, 249
Chitale, A. G., 425
Chmura, M., 213
Chollet, P., 62
Claassens, J. W., 374
Cleek, G. W., 395
Clegg, P. L., 85
Clewlow, G., 46
Clutterbuck, Margery, 474
Coffin, L. F., Jun., 60
Cogill, W. H., 56
Cole, A. G., 230
Coleman, B., 292
Coleman, B. D., 15
Collis-George, N., 197
Colodny, P. C., 283
Connors, H. J., 221
Conrad, C. M., 520
Contois, L. E., 403
Copley, A. L., 298
Coppock, J. B. M., 224
Cornelissen, J., 67
Cornford, S. J., 224
Cookson, M. A., 224
Cooper, R. E., 83
Cox, W. P., 254, 401
Coxon, W. F., 375
Cragg, L. H., 426, 509
Craggs, J. W., 338
Craik, D. J., 573
Cramer, W. S., 125
Culpin, M. F., 150, 151

D

Daggett, W. F., 142, 436
Dahlgreen, Sven-Eric, 355
Darnborough, G., 522
Das Gupta, A. K., 82
Das Gupta, N. N., 233, 390
Das Gupta, S., 82
Das Gupta, S. C., 233
Dash, J. G., 447
Davidson, H. W., 235
Davies, D. M., 245
Davison, P. F., 288
Dawydoff, W., 96
De Jong, M., 384
Deeley, C. W., 127, 269
Deich, A. Ya, 576
Den Braver, F. C. A., 137
Di Marzio, E. A., 352
Dietzel, A., 51
Dintenfass, L., 304, 432, 567, 568
Dixon, R. R., 411
Dixon, W., 46
Doede, C. M., 373
Doherty, O. J., 566
Dolidze, D. E., 321, 450
Donnelly, R. J., 462
Doolittle, A. K., 12
Doolittle, D. B., 12
Draker, H. C., 226
Draper, A. B., 41
Drickamer, H. G., 244
Dubois, P., 492

Dulmage, W. J., 403
Dunell, B. A., 420
Dunn, J. R., 533
Dyment, J., 404

E

Eckstein, B. H., 538
Edelmann, K., 418
Edward, J. T., 76
Edwards, D. H., 197
Efremov, I. F., 556
Eimer, 174
Eisenberg, H., 31, 128, 201
Ellis, E. G., 153
Ely, R. E., 214
Emme, F. E., 385
Emslie, A. G., 351
Engelhardt, W. V., 315
Engelter, Ad., 369
Epifanov, G. I., 59
Eppelsheimer, D. S., 502
Eshelby, J. D., 21
Evans, D., 135
Eveson, G. A., 433
Ewbank, W. J., 164
Eyring, H., 136, 446

F

Fadeeva, V. S., 297, 561
Fainman, 159
Fatou, J. M. G., 293
Feld'man, R. I., 267, 535, 542
Feltham, P., No. 4, p. 41
Ferry, J. D., 121, 124
Feughelman, M., 291, 518, 525
Finch, G. I., 82
Fincke, A., 28
Fitzgerald, E. R., 113
Flood, E. A., 393
Forry, K. E., 71
Forster, E. O., 168
Foster, E. L., 39
Fraade, D. J., 456
Frank, F. I., 487
Frei, E. H., 31
Frenkel, S. Ya, 290
Frey, H. E., 103
Fridman, E. G., 266
Friedlander, S. K., 167
Frisman, E. G., 266
Fujishige, Shoei, 423
Fujith, Hirosh, 398, 400
Fukawa, H., 311
Fulop, W., 19

G

Gaden, E. L., 133
Garber, R. I., 469
Garner, F. H., 145
Gaskins, F. H., 91, 106
Gast, I. E., 530
Gast, L. E., 98
Gavis, J., 285
Geil, G. W., 381
Gel'fand, Ya E., 199
Gent, A. N., 81, 417
Gharpurey, M. K., 264
Gibbs, D. F., 54a
Gibbs, J. H., 352
Giesekus, H., 331
Gill, W. R., 234
Girshov, L. A., 199
Goldfein, S., 110, 206
Goldschmid, O., 94
Golik, A. Z., 144
Golub, M. A., 119, 120
Golubenkova, L. I., 286
Goodman, P., 116
Gordon, J. E., 392
Gordon, M., 496
Goring, D. A. I., 532
Goriunov, J. V., 169, 463
Gotlib, Yu. J., 88
Graham, A., No. 4, p. 43
Greaves, M. J., 207
Grechanova, S. B., 584
Green, A. P., 335, 336
Greenspan, M., 451
Greenwood, N. N., 29
Grieveson, B. M., 496
Griffith, J. E., 334, 408
Griffiths, L., 44
Grobbelaar, C., 36, 210
Grobe, A., 92
Grogg, Ben, 488, 489
Grossman, P. U. A., 196, No. 4, p. 34
Gruzewski, A., 322
Gul, V. E., 117
Gul', V. E., 506
Gundiah, S., 114, 514
Gundiam, S., 416
Gupta, O. P., 160
Gurnee, E. F., 90
Gusev, K. F., 299
Gussard, K., 480
Gutowski, R., 176
Guzman, G. M., 293

H

Hagy, H. E., 66
Hahn, S. J., 136
Halden Wanger, H., 202
Halling, J., 198
Haly, A. R., 291
Hamamoto, H., 301
Hamburger, W. J., 275
Hamilton, E. H., 395
Han, S. T., 316
Happel, J., 11
Harding, S. W., 18
Haywood, R. W., 157
Heap, H., 39
Hearle, J. W. S., 194
Heinz, W., 28
Heiss, R., 574
Hempel, F., 445
Herdle, L. E., 95
Hermans, J. J., 33
Herzfeld, K. F., 354
Higginbotham, G. H., 554
Higgins, H. G., 529
Higgins, T. H. S., 17
Hill, R., 335, 337, 340
Hirai, N., 446
Hlynka, I., 171
Hodge, P. G., 332, 341
Hoff, E. A. W., 43, 204
Hoffman, L. C., 52
Hoffman, W., 422
Holman, B., 213
Hopkins, H. G., 23
Hopkins, I. L., 348
Hopkins, M. R., 25
Hubbard, W. D., 437
Huebner, V. R., 571, 572
Huque, M. M., 532
Hurd, R., 566
Hutchison, T. S., 382
Hutton, G. J., 382
Hutton, J. F., 135
Hutzen, E-H., 507

I

Ichiba, A., 311
Ichimiya Torao, 414
Innes, K. K., 154, 317
Ishikawa, K., 540
Ito, K., 258
Ito Katsuhiko, 112
Ivlev, D. D., 467

J

Jacobi, H. R., 193
Jacobson, M. J., 192
Jakob, I., 481
James, D. M., 99
Jaska, E., 35, 482
Jennings, W., No. 3, p. 27
Jenson, V. G., 145
Jobling, A., 484
Johnson, K. L., 475
Johnstone, H. F., 167
Jolie, R. M., 515
Joly, M., 581
Jones, R., No. 4, p. 37
Jordan, G. D., 147
Jung Alex., 126

K

Kadashevich, Yu. I., 181 346, 466
Kalinina, L. E., 289, 546
Kaliski, E. J., 471
Kanamaru, K., 259
Kapur, S. L., 114, 416, 514
Karabeinik, M. M., 364
Karapet' Yants, M. Kh., 564
Kargin, V. A., 101, 550
Karlikov, D. N., 144

VOL. 1 1958

Kaufman, H. S., 123
Kawai, T., 122
Kawata, K., 510
Keeney, R., 254
Keilen, J. J., 323
Kelch, N. W., 385
Keller, E. K., 64, 394
Kennedy, A. J., No. 4, p. 41
Kesler, C. E., 40, 387
Kirby, P. L., 70
Kirk, J. M., 443
Kirschmer, O., 444
Kishimoto, Akiro, 398, 400
Kitova, A. I., 148
Klare, H., 92, 93
Klein, W. G., 275
Kleinschmidt, L. R., 563
Klimov, K. I., 493
Kline, D. E., 127, 269
Klyushnikov, V. D., 468
Kolfenbach, J. J., 168
Koniger, A., 361
Kono, R., 281
Koppelmann, J., 365
Kosiyama, K., 276
Kovarskaya, B. M., 286
Koyama, R., 54, 65
Kozlovskaia, E. I., 394
Krenkler, K., 367
Krigbaum, W. R., 122
Krutetskaya, G. P., 117
Kukin, G. N., 274
Kusakov, M. M., 162, 438
Kushner, L. M., 437
Kusov, A. B., 247, 547
Kuznetsov, L. S., 570

L

Lahiri, A., 390
Lakhanpal, M. L., 393
Lammiman, K. A., No. 3, p. 28
Lancaster, E. B., 50
Landel, R. F., 121
Larsen, H. A., 244
Lavrent'ev, V. V., 250
Laws, V., 539
Le Sota, S., 587
Leaderman, H., 163
Learmonth, E. M., 524
Leeman, E. R., 36, 210
Leeuwen, J. van, 67
Leeuwerik, J., No. 4, p. 34
Leibovic, K. N., 435
Leont'ev, B. I., 493
Levi, F. A., 38
Liberman, Yu. M., 342
Lichtman, V. I., 63, 379
Lilley, H., 222
Lindemann, N., 453
Lindley, H., 118
Lindley, P. B., 81
Lin'kov, E. M., 236, 498
Litwinszyn, J., 320
Longworth, R., 545
Lord, P., 27
Loska, S. J., 35, 482
Loska, S. J., Jun., 49
Losty, H. H. W., 235
Lubben, H., 315
Lutskii, A. E., 319
Lyons, W. J., 183

M

Mack, C., 302
Mackenzie, D. K., 37
Mackenzie, J. D., 318
Madejski, J., 173, 177
Maes, E., 47
Majer, J., 543
Major, H. M., 262
Makarov, L. O., 146
Malinin, N. I., 557
Mamedov, Ya. D., 182
Mandelkern, L., 428
Mandell, E. R., 412
Manjoine, M. J., 212
Mansfield, E. H., 22
Manson, J. A., 509
Marathe, M. N., 511
Mardles, E. W. J., No. 3, p. 27
Marin, J., 334, 408
Markham, M. F., 230
Markov, S. N., 299
Markovitz, Hershel, 107, 108
Marsal, D., 329
Marsh, D. M., 392
Mason, P., 80
Mason, S. G., 473, 532
Mathieson, A. R., 256, 531
Mathur, K. B., 145
Mattern, P. J., 172
Matthews, J. B., 135
Matsumae Kazuyoshi, 414
Matsumoto, I., 540
Mattyasovszky-Zsolnay, L., 242
Maude, A. D., 26, 434
Mavis, F. T., 207
Maxwell, Bryce, 126, 270
McCallion, H., 245
McCoubrey, J. C., 20, 330
McCrakin, F. L., 470
McCrum, N. G., 273
McDowall, I. C., 195
McKelvey, J. M., 285
McKennell, R., 53
McKenzie, A. W., 529
Meakin, J. D., No. 4, p. 41
Meerman, P. G., 439, 454
Meder, H., 453
Melmi, Diane, 489
Mencik, Z., 479
Menyhard, I., 240
Mercurio, A., 399
Merz, E. H., 401
Meskat, W., 422
Metzner, A. B., 132
Meyerson, M. R., 383
Mikesell, R. P., 541
Mikhailov, I. G., 272, 313
Mikiashvili, Sh. M., 158
Miner, C. S., 562
Minsky, E. M., 464
Mironova, A. K., 267, 535, 542
Mitchell, R. L., 94
Mitchell, T., 525
Mogilnikova, T. T., 469
Mooney, M., 14, 191
Moore, W. R., 431
Morawetz, H., 545
Morfitt, G. L., 413, 534
Morris, B., 477
Morris, P. R., No. 3, p. 28
Morrison, R. F., 226
Morton, Dr, M. E., 231
Mulder, H., 137
Mulhearn, T. O., 368
Muller, F. H., 251, 369
Mullin, W., 452
Munzel, K., 523
Murakami, K., 399
Murdock, J. W., 387
Muus, L. T., 271

N

Nagamatsu, K., 276
Nagamatsu, Kazuo, 537
Nagels, P., 441
Nakamura, K., 294
Nakada, O., 260
Najedly, E., 543
Nerpin, S. V., 556
Newcomb, T. P., 37
Newman, S., 277
Nichiporenko, S. P., 72, 560
Nielsen, L. E., 254
Nilova, Yu. I., 247, 547
Nishioka Atsuo, 414
Niven, C. D., 503
Novikov, A. S., 257, 544, 549
Novitskii, B. G., 225
Novozhilov, V. V., 346, 466

O

Oberstar, H. E., 562
Obukhova, E. M., 319
Oding, I. A., 378
O'Donnell, T., 197
Ogino, K., 287
Oldroyd, J. G., 1, 349
Oldekop, W., 7
Oliver, D. R., 554
Olson, D. M., 211
Olson, E. M., 538
Olszak, W., 321
Ookawa, T., 294
Orr, R. S., 520
Ortega, J. J., 386, 483
Oskin, E. T., 270
Osokina, D. N., 495
Otsuka, A., 501
Ottaway, F. J. H., 224

P

Parikh, N. M., 243
Parker, R. A., 437
Parker, W. D., 109
Parkin, J., No. 4, p. 32
Parramore, T. S., 372
Parratt, N. J., 504
Parrish, M., Jun., 371
Patrick, R. L., 373
Payne, A. R., 402
Peck, L. G., 351
Pence, J. W., 324
Penny, F. D., 358
Perricone, A. C., 223
Pertzov, N. V., 380, 463
Perzyna, P., 321
Petrov, A. A., 438
Philip, J. R., 575, 577
Philippoff, W., 91, 105, 106
Pickup, 100
Pieski, E. T., 271
Pigman, G. L., 314
Pirtz, D., 75
Platt, M. M., 275
Please, A., 300, No. 4, p. 27
Plumat, E., 68
Polivka, M., 75
Polonskii, T. M., 140
Pomey, J., 58
Popov, M., 362
Porter, M. R., 531
Powell, D. A., 558
Prager, S., 130
Prager, W., 16
Preston, R. D., 522
Priss, L. S., 13, 248, 347, 548
Prod'homme, M., 69
Pryle, W. H., 212

Q

Quistwater, J. M. R., 420

R

Rachinger, W. A., 505
Rais, G. B., 391
Rampolla, R. W., 580
Rao, V. V., 233
Rathenau, G. W., 384
Ratinov, V. B., 388
Raw, C. J. G., 17
Reaves, C. A., 234
Rebenfeld, L., 521
Rebinder, P. A., 308
Ree, T., 136
Reed, R. P., 541
Rees, B. L., 111
Regirer, S. A., 188, 353
Rehbinder, P., 379, 380
Reid, W. H., 189
Reiner, M., 585
Reitsma, L. J., 502
Reitzel, J., 219
Rempp, P., 508
Rezabek, A., 5
Rhodes, R. P., 133
Richards, J. C., 553
Richards, T. Ll., No. 4, p. 42
Richter, G. A., 95
Riddlestone, H. G., 239
Rigby, B. J., 519
Ritland, H. N., 66
Rivlin, R. S., 3
Roberts, J. E., 484
Robertson, W. D., 366
Robinson, G. C., 323
Robinson, J. V., 131
Robson, R. C., No. 4, p. 32
Rodeyns, A., 261
Roetling, J. A., 486
Roscoe, R., No. 3, p. 24, 555
Rosenberg, L. D., 146
Rosenberg, S. J., 383
Rozanski, V. N., 463
Rozenberg, T. I., 388
Rozhanski, V. N., 169
Rozhansky, V. N., 380
Rozovskii, M. I., 185
Rudd, J. F., 89, 90
Ruoff, A. L., 487
Rutgers, R., 309, 310
Rutherford, P. P., No. 3, p. 28
Rutyers, A. J., 441
Rybnikar, F., 512

S

Saal, R. N. J., No. 4, p. 29, No. 4, p. 36
Sadron, C., 508
Saito, K., 122
Samarin, A. M., 158
Samsonova, T. I., 290
Samuels, L. E., 368
Sandiford, D. J. H., 284
Sandstedt, R. M., 172
Sarkar, S., 233
Sarker, S., 390
Sauer, J. A., 127, 269, 409
Scanlan, J., 533, 551
Schallamach, A., 246
Scheidegger, A. E., 357, 389
Scheraga, H. A., 428
Schiefer, H. F., 470
Schiller, K., 74
Schirott, 303
Schneider, W. J., 98, 530
Schnurmann, R., No. 3, p. 26
Schulken, R. M., Jun., 30
Schurz, J., 97, 427, 429
Scott Blair, G. W., 34, 222, 476, 583
Severs, E. T., 102
Seville, A. T. K., 392
Shalopalkina, T. G., 569
Sharples, A., 262
Shaw, W. G., 325
Shchukin, E. D., 169, 380, 463
Shchukin, E. F., 232
Shebalin, O. D., 448
Shimizu, T., 311
Shiraki, Y., 139
Shooleikin, V. V., 578
Sigler, A., 213
Simmens, S. C., 370
Simon, I., 219
Singh, N. M., 20, 330
Sippel, A., 507
Skowronski, J., 179
Slichter, W. P., 412
Slonimskii, G. L., 286
Small, P. A., 363
Smith, C. W., 271
Smith, G. S., 10
Smith, J. C., 470
Smith, L. M., 80
Smith, M. C., 211
Smith, T. G., 285
Smyth, Ch. P., 580
Sneck, H. J., 8
Snoke, H. R., 563
Sogolova, T. I., 101, 550
Sokolov, S. I., 267, 542
Sokolovskii, A. L., 570
Solaja, V., 228
Solov'ev, V. A., 272, 536
Solowjew, A. N., 274
Southwell, R. V., 343
Spaak, A., 410
Spark, L. C., 522
Sparks, M. L., 30
Spath, W., 491
Spinner, S., 395
Sreekantath, G. M., 359
Srivastava, K. P., 455
Stakhanov, I. P., 356
Stalikova, G. D., 388
Standridge, N. N., 324
Stein, R. S., 415
Steinhilber, 303
Steketee, J. A., 345
Stephan, H., 45
Stephenson, C. E., 42
Sterling, C., 48, 129
Stern, D. M., 282
Sternlicht, B., 8
Stolte, H., 152
Stone, D. E., 4
Strasburger, H., 497
Street, N., 472, 586
Strella, S., 213
Striker, L., 442
Stupochenko, E. V., 356
Sweeting, O. J., 87

T

Takahashi, S., 527
Takemoto Tatsuro, 537
Takemura, T., 263
Takemura, Tetuo, 424
Tardif, H. P., 62

TARKOW, H., 292, 397
TATE, D. R., 209
TAYLOR, J. H., Jun., 55
TEETER, H. M., 98, 530
TEKINALP, B., 333
TEMME, TH., 215
TERRY, N. B., 350
THIELE, M., 361
THOMAS, A. G., 417, No. 4, p. 38
THOMAS, W. F., 238
THOMSEN, L. C., 571, 572
THROWER, E. N., 80
TITKOV, N. I., 73
TITOV, A. I., 308
TOBOLSKY, A. V., 283, 399
TOKITA, N., 259
TOLSTUKHINA, F. S., 257, 544, 549
TOOR, H. L., 104
TORDELLA, J. P., 86
TOROPOV, A. P., 148
TRAPEZNIKOV, A. A., 543a, 569
TRAXLER, R. N., 442
TREVES, D., 31
TRIPP, V. W., 520
TROFIMOVA, V. I., 247, 547
TROPIN, V. P., 299
TROUT, D. E., 229
TSARSKII, L. N., 506
TSCHIEGG, C. E., 451
TSHOEGL, N. W., 457
TSVETKOV, V. N., 280
TUIJNMAN, C. A., 33
TURNER, S., 43, 204
TUZI, Z., 510
TYABIN, N. V., 295, 460

U

UMSTATTER, H., 478
USKOV, I. A., 296, 559

V

VAKULENKO, A. A., 458
VAN DER VEGT, A. K., No. 4, p. 40
VANECEK, V., 9
VASILIEV, L. I., 500
VASSILION, B. E., 218
VAUGHAN, W. A., 373
VEILER, S. J., 63, 379
VENING MENESZ, F. A., 339
VENKATACHARI, T. E., 160
VERGHESE, C. A., 359
VERNON, E. V., 217
VESTERDAL, H. G., 168
VIL'NITS, S. A., 506
VINOGRADOV, G. V., 295, 460
VITOVEC, J., 5
VLADOVETS, I. N., 308
VOLAROVICH, M. P., 299, 557
VOYUTSKII, S. S., 289, 546

W

WADE, K., 29
WADE, P., 138
WALKER, J. A., 219
WALKER, W. D. C., 109
WALSH, E. K., 123
WARD, A. F. H., 27
WARD, I. M., 278
WARD, S. G., 554
WARRICK, E. L., 255
WASSERMANN, A., 83
WATANABE, M., 54, 65
WATANABE, MUNED, 414
WATERMAN, H. I., 67
WATSON, W. F., 533, 551
WEATHERWAX, R. C., 292
WEBBER, A. C., 203
WEBER, N., 306
WEBER, W., 449
WEEKS, D. J., 220, 376
WEINTRITT, D. J., 223
WEIR, C. L., 410
WERNER, A. C., 407
WESSEL, E. T., 212
WEST, D. C., 268
WESTOVER, R. F., 406
WEYL, W. A., 52
WHITE, H. S., 516
WHITMORE, R. L., 134, 434
WIBERLEY, S. E., 306
WIDDOWSON, A. E., 216
WILKINSON, C. E., 442
WILKINSON, R. W., 477
WILLBOURN, A. H., 42, 517
WILLIAMS, H. O., 205
WINKLER, F., 186, 421
WOOD, L. A., 552
WOODWARD, A. E., 127, 269, 409
WRIGHT, P. J. F., No. 4, p. 25

Y

YANG, JEN TSI, 579
YIHARA, Y., 527
YOKOBORI, T., 501
YOSHITOMI, TATSUYA, 537
YOSHITOMI, T., 276
YOUNGS, E. G., 197
YSYLEV, L. M., 158
YU PAO-SHAG, 253
YUFIN, V. A., 155

Z

ZAUSTIN, M. V., 328
ZAWADSKI, J., 180
ZENZ, F. A., 170
ZETTLE MOYER, A. C., 55
ZIEBLAND, H., 404
ZIEMBA, S., 175
ZIFFLE, H. M., 520
ZIMM, B. H., 32
ZIMM BRUNO, H., 494
ZIMMERL, W., 427
ZOTOVA, K. V., 307
ZUEV, YU. S., 57

RHEOLOGY ABSTRACTS

Subject Index to Volume I

Prepared by MR. R. JONES, University College, Swansea.

VOL. 1 1958

A

absorption
  microwave, and molecular structure in liquids, 580
  moisture, thermodynamic relations, 194
acid etching of well-glasses, 239
adherence of blood contacting foreign surfaces, 298
adhesion
  investigation of, in gelatin films, 292
  of elastic solids, 475
  tacky, 497
  ultracentrifuge for testing, 373
adhesives, the tackiness of, 166
adsorption
  of gases and vapors, contractions of carbon on, 393
  in paint systems, 567
adsorption errors in capillary viscometry, 478
adsorption plasticisation in pressure of metals, 379
alcohol
  –sulphite residue, for the improvement of drilling mud, 326
  unsaturated fatty, reactions of, 98, 530
alginate mucilages, rheological properties of, 523
alloys, liquid binary, viscous and electrical properties of, 499
alloy steels, impact properties of, 383
aluminium
  internal friction of, influence of strain rate and recovery, 500
  subject to thermal and mechanical treatments, 382
amylogram curves, characteristics of, effect of bowl speed upon, 49
asphalt
  changes in, during blowing operations, 563
  concrete, rheological study of, 386
  mixtures of petroleum bitumen with, 303
  rheological properties of, development of cracks in, 443
  roof coating, 442
  stability tests on, 300

B

bakery fats, tests in the assessment of, 224
Bauschinger effect, theory of plasticity and, 181
bentonite suspensions, properties of, influence of electrolite on, 296, 559
biaxial straining, instrument for, 196
birefringence
  anomalous systems, 581
  measurement in complex structures, 370
bitumen films, physical properties of, 302
bitumens
  brittleness and viscosity of, influence of rubber on, 80
  low temperature behaviour of, 367
  mechanical and rheological properties of, 444
  mechanical test for, composition containing tar and, 215
  mixtures with asphalt, 303
  thermoplasticity and structural viscosity of, 445
  use in road construction, 109
blood
  adherence and viscosity of, plasmatic zone in, 298
  flow of, relation to the vessel wall, 583
bread, retardation of staling rate of, 45
brick, apparent compressive strength of, 385
brittle point measurement of P.V.C., 205
butadiene and nitrocellulose copolymers, compatibility of relaxation behaviour, 289, 546
butter
  applied to working machines, 137
  macrotome for preparing surfaces of, 374
  manufacture of, formation and structure in milk fats, 308
  spreadability and hardness of, instrument for measuring, 571, 572

C

cake crumb, effect of storage temperature on firming of, 324
calcite, dislocation in 391
calcium, viscosity of, 151
carbides, fracture and slip in cemented, 243
carbon, contractions of, on adsorption of gases and vapors, 393
carbon steels, on tempering, elastic constants of, 230
cast iron
  viscosity of, 361
  effect of D.P. and concentration on physical properties, 93
cellulose
  false viscosity in, 95
  filaments formed from viscose, 92
  influence on paper properties, 529
  viscoelasticity of derivative films, 294
  viscometric study of, 293
  viscosity–chain length relations for, 94
  viscosity–molecular weight relationship for, 430
cellulose (ethyl)
  hydrodynamic characteristics and polyidispersity of, 290
  viscosity–molecular weight relationship, 431
cellulose nitrate, viscosity of, 288, 425, 528
cellulose tributyrate, viscosity of, 121
cellulose trinitrate, molecular size and configuration of, 532
cement, properties of, 73
centripetal pump effect in a vacuum pump, 585
ceramic glazes, fineness and consistency of, 226
ceramics
  properties of, 72
  quality control of, equipment for, 223
  rheological curves for, 560
ceramic slips, fluidity of, 305
chocolate, rheological properties of, 574
chromium, electrical resistivity of, effect of plastic deformation on, 231
clays
  deformation of, 561
  deformation of, orientation of particles in, 297
  humus content of, treatment with hydrogen peroxide, 139
  nature and dispersion in, 440
  temperature effect on, 140
coal, dilatometric properties of, 233, 390
collapse of rigid plastic plates, 22
colloids, rheological behaviour of, 483
compatibility equations of strain rate and strain, integrability of, 344
compressibility of solids, measuring of, 219
concrete
  compressive strength of, 387
  creep studies of, loading system for, 75
  morphology of fissures in, 241
concrete asphalt, rheological study of, 386
concrete beams
  impulse testing of, 207
  subject to shear and bending stresses, shear fracture of, 240
consistency
  of oil-solid systems, increase by adding glycerine, 562
  milk-starch pudding, 309, 310
continuous stream analysis, advantages of, 456
cotton cellulose, supermolecular structure and behaviour of, 520
cracks
  in asphalt roofs, 443
  influence of deformation on, 57
creaming in assessment of bakery fats, 224
creep
  apparatus, 366
  of glass reinforced plastics, 110
  of metals, equations for, 378
  in polyethylene, at elevated temperatures, 411
  relaxation for combined stresses, 334
  and relaxation, integral equations of, 185
  relaxation of Plexiglass, 408
  tests, using generalized Kelvin-Voigt model, 186
  of viscoelastic substances at varying temperatures, 348
  of wool fibres in water, 518
crystallinity
  in silicone rubbers, 255
  influence on the behaviour of polymers, 513

D

deformation
  anisotropy of, 465
  of clay pastes, 297, 561

deformation--*continued*
effect on electrical resistivity of chromium, 231
effect on formation of cracks, 57
of elastomers, effect of time and temperature, 402
of phenolphthalein, 244
thermodynamic relations among stresses, moisture absorption and, 194
in welding of PVC sheets, 202
degradation of polymer solutions, 516
deoxyribonucleate, birefringence and viscosity of, effect of urea, 531
deoxyribonucleic acid, viscosity of, 128
detergents, turbidity and viscosity measurements on, 437
dies for plastic extrusion, design of, 220, 376
diffusion coefficient, effect of temperature and solute volume on, 154
disc rheometer for shortenings, 35
discs, elasticity and anelasticity of, 38
dislocations in semi-infinite elastic medium, 345
disperse systems
calculating the flow of, 295, 460
two dimensional, rheology of, 1
distillation columns, performance calculations, 452
distortion of fluid drops, 145
dough
effect of pH on, 171
influence of soya flour on, 524
relaxation of externally applied stress in, 489
drilling mud
movement of shaft body through, 439
reagent for the improvement of, 326
dynamics
of chain molecules in dilute solutions, 265
of incompressible materials of variable viscosity, 188, 353

E

elastic constants, relations for n dimensional systems, 457
elastic field of an ellipsoidal inclusion, 21
elasticity
kinetic theory of high, 13
of ice, 498
in non-polymer crystals, 392
and plasticity, 339
of polymers, influence of crystallinity on, 513
elasticity—*continued*
of rubbers, 543a
of rubbers, dependence on molecular weight, 248, 548
of soft gels, 34
of solids, 377
elastic materials
adhesion of, 475
bending of a circular plate, 333
flexure of cylinders, 2
propagation of waves in, 338
viscosity of Maxwellian, 14
elastic moduli, apparatus for the determination of, 217, 218
elastic strain, uniqueness theorem, 340
elastomers
brittleness temperature testing of, 203
deformation of, effect of time and temperature, 402
statistical theory of, application to keratin fibres, 291
elastoviscous flow, of bulk Hevea rubber, 253
elastoviscous liquids, non-Newtonian effects in, 349
elastoviscous properties of plasticised poly (vinyl chlorides), 543
electrical resistivity of chromium, effect of plastic deformation on, 231
electroviscous effect in silver iodide, 441
electroviscous equation, derivation of, 472
emulsions
stability of, 162, 438
storage stability of, 141
enamels, viscosity of, effect of ferric oxide on, 584
equation of state for rheology, 331
ethylene, stress relaxation and dynamic properties of, 270
extensibility of crystalline region in polymers, 403
extrusion, role of water in, 323

F

fabrication, effect of polythene on, 85
fabrics, load extension tester for, 485
failure and steady flow, 484
fatigue failure in textile materials, 183
ferric oxide effect on the viscosity of enamels, 584
fibres
Poisson's ratio for, 487
tensile testing of, 486
filaments, effect of length on tensile elongation, 507
film, load extension tester for, 485

filter pressing, the mechanism of, 195
firming of cake crumb, 324
fissures in concrete, morphology of, 241
flour
  influence on bread doughs, 524
  mixing and baking characteristics of, 172
  water absorption of, 47
flour-water batters, mixing characteristics of, 50
flow
  action and viscous, 26
  between rotating cylinders, 25, 461, 462
  birefringence and stress, 581
  of blood in relation to the vessel wall, 583
  in a curved channel, stability of, 189
  of disperse systems, 295, 460
  equations of plastic substances, 28
  in glass to metal seals, 66
  of grains through apertures, 553
  in granular media, dispersion of soluble matter, 156
    law for a Newtonian liquid, 110
  in liquid silicates, 318
    measurements, devices for, 375
  of Newtonian fluids, verification of the free space viscosity equation, 12
  of non-Newtonian fluids, 132
  of non-Newtonian fluids and turbulent Newtonian fluids, relation between, 3
  in pipes of arbitrary cross-section, of non-Newtonian liquids, 4
  of polymers, orientation and birefringence in, 266
  of polythene, effects on fabrication, 85
  of polyvinylalcohol, 101
  in porous media, 464, 575
  of starch powder and mixtures, 573
  of steam–water mixtures, 157
  of suspension of spheres, turbulent, 434
  of viscous fluid between porous parallel walls, 312, 450
  of viscous liquid on a rotating disk, 351
  plastisol, factors affecting, 103
    with exchange of mass, energy and momentum, 320
flow curves interpreting of, 429
fluidity of ceramic slips, 305
foaming influence on rate of flow, 436
forgeability evaluation tests for, 41
fracture
  and slip in cemented carbides, 243
  mathematics available for describing, 357
  of concrete beams, 240
  of mild steel, stress conditions, 501
free-flowing media, statics of, 467
friction
  of aluminium, influence of strain rate and recovery on, 500
  of bulk polymers, 111
  of glass, internal, 52
  lubricated, 58
  of overstressed microregions in a solid, 469
  ploughing theory of, yarn surface, 471
  resistance to shear, thin surfaced layers of solids, 59
  of rubber, external, 250
  of rubber, inflated tires on ice, 503
  in soda silicate glasses, 71
  temperature rises on rubber, 246
  transition temperature for damage type, 60

G

gamma radiation
  on commercial lubricants, 161
  on rubber solutions, 82
gases
  adsorption of, carbon on, 393
  molecular interactions and properties of, 455
gas streams, turbulent, deposition of suspended particles from, 167
gauge length and elongation of filaments, 507
gelatinization of starch materials, 488
gelation, kinetic theory of, 556
gels
  comparison of strength with concentration, 138
  effect of strain rate on properties, 569
  elastic properties of, 34
  for studying strain, 495
  viscometric study of formation, 570
gel strength, of ceramics, testing equipment for, 223
geostatic pressures, calculation of, 322
glass
  effect of composition on the internal friction of, 52
  elastic properties of, 64, 394
  flow to metal seals, 66
  heating of, 395
  internal friction in, 71

glass—*continued*
non-elastic behaviour of, 70
reinforced plastics, creep of, 110
structure and elastic properties of, 237
structure of, heat treatment and viscosity of, 68
transformation range, viscosity of, 69
transition, nature of, 352
transition period, stabilization of, 65
viscosity in the working range of, 51
viscosity of, 7, 67, 564
glass fibres, strength of, 238, 504
glycerine, added to oil-solid systems, consistency increase due to, 562
grain, flow of, through apertures, 553
granular media, dispersion of soluble matter through, 156
graphite, plasticity of, 235
gravity flow rates, prediction of, 170
grease
consistency of, 221
lubricating industry, 164
mechanical properties and thixotropy of, apparatus, 493
performance of, yield-stress factor, 135
thixotropy and its application to, 136
gutta-percha, properties of, dependence on structurization, 550
gypsum
setting of, rheological investigations in, 388
thickening of slurries of, 558

H

hardness, measurement of, 126
heat
in incompressible liquids, generation and conduction of, 126
generation in tensile testing, 369
helium, viscosity of, 447
Hookean solid, theory of peeling through, 184
hydrodynamics, relative movement of a pair of spheres, 191
hydrogen bonding in copolymers, 545
hydrogen peroxide, effect on the humus content of clays, 139

I

ice
characteristics of, method of finding, 236
elastic characteristics of, 498
friction of rubber tires on, 503
impact of droplets on solids, damage studies, 227
impact test in material testing, 491
indentation test, study of deformed zone, 368
indium
tensile strength of, 502
viscosity of, 150
inks, work on printing, 143
instability of viscoelastic media under compression, 24
iodide, electroviscous effect in, 441
iron under stress, 384

J

jewelry bronze, mechanical and physical characteristics of, 229
journal bearings, cavitation in lubricants, 314

K

keratin fibres
supercontracted, application of statistical theory of elastomers, 291
variability of set in, 525

L

lambda point, liquid helium near, viscosity of, 447
lacquer additives, paint and, 142
leather, physico-mechanical properties of, 225
load cells, bridge circuit for, 372
locking materials, mechanics of, 16
lubricants
drawing of metals in the presence of, 63
external pressure properties of, 200
gamma radiation on, 161
and pressure working of metals, 379
synthetic ester, 159
viscosity classification of, 147
lubricating film, pressure distribution in, 192
lubricating grease, industry of, 164
lubricating oils, viscosity–temperature relationship of, 153
lubrication and wear, 327

M

magnesium, the viscosity of, 151
mastication of rubber, 418
melt viscosities in copolymers of styrene with methacrylate acid, 545

mercerisation, cotton fibres and their response to, 521
mercury, effect on the strength of metallic single crystals, 380
mesomorphic state of liquid crystals, 325
metal single crystals
  effect of thin coatings of mercury on, 380
  unhomogeneous plastic flow of, 232, 463
metals
  creep of, general equations for, 378
  drawing of, in the presence of lubricants, 63
  pressure working of, 379
methylacrylate, mechanical properties of, 282
methyl-methacrylate, photo-elastic effect in, 280
milk
  physical changes in, 476
  setting of, measuring of, 222
  –starch pudding, consistency of, 309, 310
milk fat, formation of structure in, manufacture of butter, 308
mineral oil
  recovery by water displacement, 329
  thermal treatment of wells in, 453
mixing
  during pumping of petroleum products, 155
  efficiency of processing equipment, 168
  of slurries, 435
mixtures
  flow properties of, 573
  macro-physical properties of, 319
molecular structure
  of liquids, relation between viscosity and, 123
  and microwave absorption in liquids, 580
molecular weight
  distribution by stress relaxation, 399
  effect on the elasticity of finished rubber, 248
  of ethyl cellulose, relationship between viscosity and, 431
  and intrinsic viscosity of Buna-S, 249
  –intrinsic viscosity equation, constants in, 262
  and intrinsic viscosity of linear polyethylene, 271
  method, 18
  of styrene polymerized by di- and tri-chloride acid, 256
  studies in vinyl ether polymers, 98
molecular weight—*continued*
  –viscosity relationships for cellulose acetate, 430
  –viscosity relations for polychlorotrifluoroethylene, 123
monofilaments, relaxation behaviour, under oscillatory tensile stress, 422
moulding, spiral flow, 44
mucilages, rheological properties of, 523

N

nitrocellulose
  and butadiene copolymers, compatibility of, 289, 546
  intrinsic viscosity of, 288
  viscosity studies on, 160
nomenclature
  for linear viscoelastic behaviour, 163
  rheological, 458
noodles, physical properties of, 311
nylon
  equation of state for, response to environment, 538
  load–deformation curves for, 539
  mechanical properties of, 127, 540
  plasticizing effect of water vapour on, 419
  stress relaxation in, 276

O

oil
  displacement by water on porous substances, 315
  viscosity–temperature relations of, 153, 190
  –water interface, properties of surface layers at, 162, 438
oil emulsions, stability, 162, 438
oil-solid systems, addition of glycerine to, consistency increase, 562
organic liquids, apparatus for the viscometry of, 477
organoxanthate, state of solution of, rheological measurements of, 427

P

paint
  adsorption and some rheological phenomena in, 567
  and lacquer additives, 142
  rheological investigations of, 566
  storage stability of, 141

paint mill, production rate in, 55
paint vehicles, study in, 304, 568
paper, structure and properties of, 529
paraffin, mechanical properties of, vibrator method, 272
peats
  changes in, on freezing, 299
  rheological properties of, 557
peeling through a Hookean solid, 184
petroleum mixing during pumping of, 155
phenolphthalein, plastic deformation of, 244
photoelastic coefficient for polymers, 88
photoelasticity
  of non-homogeneous and anisotropic bodies, extremum theorems in, 321
  of polymers, 280, 510
  of polystyrene in the glassy state, 89, 90
photoelectric flow birefringence instrument, 494
pigment suspensions in polymer solvents, rheological classification for, 432
plasmatic zone in blood circulation, 298
plastic deformation
  effect on electrical resistivity of chromium, 231
  of overstressed microregions in a solid, 469
  of phenolphthalein, 244
  in welding P.V.C. sheeting, 202
plastic flow
  of bulk Hevea rubber, 253
  of metal single crystals, 232, 463
plastic yielding of shallow notched bars, 336
plasticity
  Bauschinger effect taken into account, 181
  dynamical theory of, work hardening and, 173
  elasticity and, 339
  equations in the theory of, 342
  of gamma irradiated PTFE, 414
  general equations of, 467
  of graphite, 235
  laws of, of strain hardening materials, 468
  piecewise linear, 332, 341
  of polymers, influence of crystallinity on, 513
  theory of, residual micro-stresses, 466
  theory of plates, 22, 23
plasticity—*continued*
  of water vapour on nylon, 420
plastics
  bending of circular plate, 333
  bending strength of, 492
  brittleness temperature testing of, 203
  creep of glass reinforced, 110
  deformable region in, 335
  flow equations of, 28
  impact testing of, 406
  mechanical properties of, temperature dependence, 112
  microstructure of, 419
  physico-mechanical properties, 225
  propagation of waves in, 338
  rectilinear motion of, 4
  rheological properties of, 407
  rupture and impact stresses in reinforced, 206
  softening point test for, 42
  tensile properties of, 404
plastisols
  factors affecting the flow of, 103
  viscosities of, at elevated temperatures, 102
plasto-elasticity of rubber, 544
Plexiglass, creep relaxation of, 408
polyamides, glass temperature of, 490
poly-γ-benzyl-L-glutamate, non-Newtonian viscosity of, 579
polycaproamide, viscometry of, 96, 512
polycaprolactam fibres, influence of heat treatment on, 279
polychlorotrifluorethylene, viscosity-molecular weight relationship for, 123
polydispersity of ethyl cellulose, 290
polyelectrolyte, influence of ion exchange on, 83
polyesters, mechanical properties of, mylar and dacron strands, 541
polyethylene
  capillary flow of molten, 86
  creep in, at elevated temperatures 411
  discontinuity of flow curves of, 268
  effect of thermal history on the dynamic modulus of, 269
  intrinsic viscosity and average molecular weight of, 271
  low temperature brittleness testing of, 204
  mechanical properties of, vibrator method, 272
  mixtures of polyisobutylene and, tensile strength of, 535
  molecular structure in, 412

polyethylene—*continued*
moulding, 410
preparation structure and properties of, 87
viscoelastic properties of, 536
polyethylene film, mechanical properties of, 413, 534
polyethylene terephthalate
cold drawing of, 277
hydroxyl and carboxy end groups in, 278
polyisobutylene
flow curves, flow birefringences, and normal stresses of, 105, 106
mixtures of polyethylene and, tensile strength of, 535
normal stress effects in, 107, 108
polymers
addition of plasticizer to, 267, 542
anomalous behaviour of, 114, 122, 416
cellulose tributyrate, viscosities of, 121
destruction and time dependence of strength of, 252
diffusion controlled stress relaxation in, 398, 400
dynamical testing of, 421
flow characteristics of, 516
glass transition in, 517
hydrogen bonding and melt viscosities in, 545
influence of crystallinity on, 513
infrared streaming dichroism of, apparatus, 371
long chain, viscosity of, 264
mechanical breakdown, 15
melt viscosity of, hydrostatic pressure effect on, 126
non-Newtonian viscosity of dilute, 115
orientation and birefringence in flow of, 266
photoelastic behaviour of, 510
photoelastic coefficient for, computation of, 88
preparation and viscosity behaviour of, 509
resonance dispersion in, at audio-frequencies, 113
rupture process and rate of deformation of, 117
shear degradation of, dependence on concentration, 116
solvent systems, critical concentration effects in, 426
static friction of, over temperature range, 111
polymers—*continued*
stiffness of the chain of, 415
straining of, 258
strength properties of, 405
study of 3 : 3 bischloromethyl oxa-*cyclo*butane, 284
study of crystalline regions in, 403
surface tension of, 397
vibrating viscometer for relaxation studies on, 32
viscoelastic behaviour of, 259, 260, 424
viscometer for rapid measurements of, 30
viscosity behaviour of, 263, 514, 515
poly(methyl acrylate) gel, expansion–contraction behaviour of, 526
poly(methylmethacrylate), dielectric and dynamic properties of, 281
poly-n-hexyl methacrylate, mechanical properties of, 124
poly - p - tertiarybutylphenyl, - methylacrylate, photo elastic effect in, 280
polystyrene
dynamic viscosity and shear modulus of, 254
photoelastic properties of, 89, 90
polytetrafluoroethylene
gamma irradiated, viscosity and plasticity of, 414
low temperature transition in, 273
viscoelastic properties of, 537
polythene
flow properties of, effect on fabrication, 85
low temperature brittleness testing of, 43
mechanical properties of, effect of pile irradiation, 409
sound velocity and damping in, 84
polyvinyl acetate
in toluene, precision viscometry of, 33
non-Newtonian behaviour of, 114
polyvinyl alcohol
anomalous behaviour of, extinction angle of, 423
flow mechanism of, 101
polyvinyl chloride
effect of the addition of plasticizer on, 267, 542
elastoviscous properties of, 543
polyvinyl emulsions, stability of, 141
porcelain, mechanical strength of, 242
porosity
and conditions governing fluid motions, 577

porosity—*continued*
and equations of flow, statistical foundation, 464
and influence of surface tension, 315
and pressure distribution, 197
and transient fluid motions, 575
and unsteady flow of viscous fluid, 312
pressure as a strength parameter, 328
pre-stressed structures, rheology of 174
protein solutions, interpretation of hydrodynamic data, 428

R

rate of flow, influence of foaming on, 436
rate of shear
influence on the viscosity of cellulose nitrate, 425
influence on the viscosity of dilute polymers, 263
viscometer measuring shear stress to, 201
relaxation
behaviour of binary mixtures, 546
behaviour of monofilaments, under oscillatory tensile stress, 422
creep, for combined stresses, 334
creep, of Plexiglass, 408
and creeping, integral equations of, 185
in dilute polymers, vibrating viscometer, 32
of extension of textile fibres, 274
of external stress in wheat dough, 489
in starch geis, of stress, 48
media, ruptures in, 356
of stress during photo-oxidation of rubber, 533
of stress in ethylene polymers, 270
of stress in false-bodied suspensions, 555
of stress in nylon, 276, 540
of stress in rubber, 551
of stress in starch jelly candy, 129
of stress in swollen polymers, 398, 400
of stress in viscoelastic substances, 348
of stress, molecular weight distribution by, 399
relaxation spectra and principle of constant isoelastic curving rates, 496
resilient materials, dynamic properties of, constitutive equations, 459
resins
mechanical behaviour during condensation, 287
thermal–mechanical study of, 286
resistivity, electrical change by elementary slip, 167
Reynold's equation for sector thrust bearing, 8
rheology
classification of systems, 582
of non-elastic media, 458
rheometer
cone and plate, 53
disc type, 35
rigid-plastic solid, uniqueness in the theory of, 337
road mixtures, mechanical tests on, 300
rock
Poisson's ratio of, lateral extensometer, 210
stress–strain curves of, 36
rotameter, calculation of Parameters, 5
rubbers
compression of, under dynamic conditions, 245
cross-linking of oriented, 79
crystallinity and orientation in, 255
elasticity of, dependence on molecular weight, 248, 548
elasticoviscous and plastic flow of, 253
external friction of, 250
filter reinforcement of, 77
frictional temperature rising in, 246
internal flaws in bounded cylinders of, 81
mastication of, 418
mechanical properties of natural and synthetic, 78
photo-elastic properties of, 544
stored energy function for, 417
strength and high-elastic properties of, 543a
stress relaxation during photo--oxidation in, 533
stress relaxation measurements on, 551
stress–strain behaviour of, 251, 552
stress waves in, 125
surface tackiness of, 100
tires on ice, friction of, 503
viscosity and brittleness of bitumens, influence of, 80
viscosity behaviour of, 119, 120, 416, 514
viscosity-structure dependence of, 549

rupture
between elastic and brittle states, 506
of high-elastic polymers, 117
and impact stresses in plastics, 206
in relaxing media, 356
testing machine for, 211

S

saponin, shear strength of films and surface layers in, 307
sedimentation of suspensions, 554
shear modulii
in frequency range 10^{-5}–10^{-1} c/s, 365
of molten polystyrene, 254
silicate glasses
structure and elastic properties of, 237
viscosity of, dependence on temperature, 564
silicate liquid, discrete ion theory in, 318
silicone oils, low temperature properties of, 449
silicone rubber, crystallinity and orientation in, 255
silicone rubber, filler reinforcement of, 77
similarity, theory of, of thermo-elasto-plastic phenomena, 177
slags, viscosity of molten, 158
slip casting, the mechanism of, 195
slit nozzles, calculation and design of, 193
slurries
mixing of, 435
thickening of, gypsum plaster, 558
viscosity of, 199
soap gels, flow properties, 306
sodium deoxyribonucleate, streaming birefringence and viscosity of, 531
softening of steel by cold working, 62
soil, physical properties of, 234
sonic methods, properties of solids by, 40
spreadability of butter, instrument for measuring, 571, 572
stability
of flow between rotating cylinders, 461, 462
of flow in a curved channel, 189
tests on rolled asphalt, 300
starch
flow properties of, 573
gelatinization of, 488
–milk puddings, consistency of, 309, 310
rheological studies on, 527
starch gels, stress relaxation in, 48
starch jelly candy, relaxation of stress in, 129
statics of free-flowing media, 467
steam–water mixtures, flow of, 157
steel
brittle fracture of, 501
softening of, cold working, 62
stiffness of chain of rubber-like polymer, 415
stirring, effect of type of shaking, 133
Stokes' equation, application to macromolecules, 76
strain
compatibility equations of, 344
gels for studying, 495
–hysteresis loops, 56
strain gauge
high sensitivity, 54a
simple system, 198
straining of high polymer solids, 258
strength of materials, need for fundamental research in, 328
stress
condition for fracture, 501
dependence of elastic constants on distribution of, 474
effects in polyisobutylene, 107, 108
influence on vibrating bars, 178
–rupture testing machine, 211
–strain curves of rock specimens, 36
–strain relation in suspension of dumb-bells, 130
stress analysis, Proc. Eleventh Conference of, 6
stress pulses in viscoelastic rods, 187
stress relaxation
in ethylene polymers, 270
in false-bodied suspensions, 555
measurements on rubber, 551
molecular weight distribution by, 399
in nylon, 276, 540
in peroxide cross-linked rubbers, 533
in polymers, diffusion controlled, 398, 400
in starch gels, 48
in starch jelly candy, 129
in viscoelastic substances, 348
stress–strain recorder, autographic, 209
stress waves in rubber rods, 125
stress yield factor in performance of greases, 135
stretching of rubber, changes in specific volume on, 247, 547
sulphite–alcohol residue, improvement of drilling mud, 326

sulphite spirit liquors, physical properties of, 316
sulphuric acid, viscometric measurement on, 96
super-elastic alloys for calibration bars, 505
surface conductance and thixotropy, 586
surface tension
and two dimensional disperse systems, 1
influence of, in porous media, 315
of viscous polymers, 397
suspensions
flow of, at low shear rates, 433
particle motions, 473
swelling of liquids, under action of ultrasound, 146

T

tackiness
of adhesives, 166, 497
of rubber compositions, 100
tar, composition of bitumen and, 215
tempering, carbon steels on, variation in elastic constants, 230
tensile tester
multi speed, 212
high speed, 213
textile fibres, relaxation of extension in, 274
textiles
dynamical tensile testing for, 421
elastic performance of, 275
fatigue failure in, 183
thermo-elasto-plastic phenomena, theory of similarity of, 177
thermoplasticity of bitumen and other materials, 445
thermoplastics
high speed tensile tests of, 214
structural viscosity of, 445
structure and viscoelastic properties of, 261
thermoplastic melts, flow properties of, 285
thixotropy
and alkyds, 99
and equilibrium, Eyring's model of flow, 355
and surface conductance, 586
of greases, 136, 493
of paint systems, 566
tin, liquid, viscosity of, 150
titanium, behaviour of, effect of low temperature, 381
trinitrate cellulose, molecular size and configuration of, 532
turbidity
of detergents, 437
of gas streams, deposition of suspended particles from, 167
of Newtonian fluids, 3
of suspensions in tubes, 434
and viscosity, in shallow seas, 448
turning tools, wear of, 228

U

ultrasonic absorption in viscous liquids, 313
ultrasonic action, swelling of liquid surfaces due to, 146
ultrasonic device for measuring properties of materials of high molecular weight, 225

V

vapour
adsorption of, contraction of carbon on, 393
–liquid equilibrium, viscosity of the liquid phase, 9
plasticization effect on nylon, 420
viscosity of, 330
vegetable fibres, structure and mechanical properties of, 522
velocity of sound by pulse method, 451
vibration
of bars, influence of initial stresses on, 178
effect of viscous damping, 175
viscoelastic bodies
instability under compression of, 24
stress pulses in, 187
vibration of, 350
viscoelasticity
of cellulose derivative films, viscometric studies on, 294
of low pressure polyethylene, 536
nomenclature, 163
of polymers, 259, 260, 424, 537
of thermoplastics, 261
viscometer
behaviour of rotation type at high speeds, 362
high shear rate, 360
high temperature, 479
for immersion in storage tanks, 358
modified moving cylinder type, 359

viscometry
and brushability, 565
review, 587
viscose
effect of D.P. and concentration on physical properties, 93
formation of regenerated cellulose filaments from, 92
viscosity of, 511
viscosities, dynamic and steady flow, correlation of, 401
viscosity
of bitumens, 80, 445
of blood contacting foreign surfaces, 298
of butadiene–butastyrene rubbers, 257
of cast iron melt, 361
of cellulose nitrate, 288, 425, 528
of ceramics, testing equipment, 223
classification of industrial lubricants, 147
of detergents, in water and in sodium chloride, 437
effects on inaccuracy of readings, 364
of enamels, effect of ferric oxide on, 584
equations for, predictions over a wide temperature range, 317
equation, studies in Newtonian flow, 12
of an expanded liquid, 148
of fluids, 188, 353, 354, 446
of gamma irradiated polytetrafluoroethylene, 414
of glass, 7, 65, 67, 69
of graft copolymers, 509
in cellulose acetate solutions, 95
in the working range of glass, 51
of linear polyethylene, 271
of liquid binary mixtures, 319
of liquid helium near the lambda point, 447
of liquid indium and liquid tin, 150
of liquid in C.G.S. units, B.S. determination of, 149
of liquid magnesium and liquid calcium, 151
of liquid phase (liquid–vapour), 9
liquids of low, 31
of Maxwellian elastic liquid, 14
measurements, melt viscometer, 363
measurements, oscillation viscometer 481
measurements, rotating cylinders, 54
–molecular structure of liquids, 144
–molecular weight equations, constants in, 262
viscosity—*continued*
–molecular weight of Buna-S, 249
–molecular weight of cellulose, 430, 431
–molecular weight of polychlorotrifluoroethylene, 123
–molecular weight of polymers, 530
–molecular weight of short chain molecules, 508
of nitrocellulose, industrial, 160
non-Newtonian, dynamics of chain molecules, 265
of oils, temperature dependance, 190
of plastisols, elevated temperatures, 102
of poly-γ-benzyl-L-glutamate solutions, 579
polymer melt, effect of hydrostatic pressure on, 126
of polymers, 115, 263, 264
of polystyrene melt, 254
of rubbers, 119, 121, 146, 514
settling rate of slurries, 134
of slags molten, 158
of slurry, automatic control of, 199
specifications, reference levels for, 165
of sodium deoxyribonucleate, effect of urea on, 531
structure of glass, 68
studies, couette viscometer for, 480
of styrene polymerized by di- and tri-chloracetic acid, 256
of suspension of spheres, 11, 131, 554
–temperature gradient, measure of, 152
–temperature relationship of lubricating oils, 153
turbulent, in shallow seas, 448
of vapours, 330
of viscose solutions, 511
viscous damping
effect on free vibrations, 175
in non linear systems, 176
of single impulses, 179

W

waves
initiation and maximum steepness of, 578
turbulent viscosity in shallow seas due to, 448
wave propagation
in elastic–plastic materials, 338
in long textile yarns, 470
in rubber rods, 125

wear
  lubricants and, 327
  of turning tools, 228
welding of PUC sheeting, plastic deformation in, 202
well glasses, acid etching of, 239
wire
  tensile testing machine for, 216
  torsion testing machine for, 208
wool, elastic properties of, 118
wool fibres, mechanical properties of, 518, 519
work hardening and the dynamical theory of plasticity, 173
working of butter, 137

Y

yarn
  stress–strain relationships in, 470
  surface friction, ploughing theory of, 471
yield point of ceramics, apparatus, 223
Young's modulus, measurement of, 37

VOL.
1
1958

Section A

THEORETICAL

1. The rheology of some two-dimensional disperse systems. J. G. OLDROYD, *Proc. Camb. Phil. Soc.*, 1957, **53**, 514—524. University College of Swansea, Wales. A theoretical investigation of the elastic and viscous properties, in two dimensions, of a dilute dispersion of small circular patches of one component in a continuous film with different rheological properties. Surface tension in each component and boundary tension between the components are taken into account, so that the theory can be applied to interfacial films at liquid–liquid or liquid–gas interfaces as well as to thicker sheets and films.

2. Second-order effects in the flexure of isotropic incompressible elastic cylinders. W. S. BLACKBURN, *Proc. Camb. Phil. Soc.*, 1957, **53**, 907—921 King's College, Newcastle-upon-Tyne, England. A mathematical analysis of the bending of a cylinder of arbitrary section.

3. The relation between the flow of non-Newtonian fluids and turbulent Newtonian fluids. R. S. RIVLIN, *Quart. Appl. Maths.*, 1957, **15**, 212—215. Brown University, U.S.A. Some analogy may exist between the turbulent Newtonian fluid and the laminar flow of a non-Newtonian fluid. It is the object of this note to pursue this line of thought and to indicate some of the phenomena which might, in accordance with it, be observed in turbulent fluids. Author

4. On non-existence of rectilinear motion in plastic solids and non-Newtonian liquids. D. E. STONE, *Quart. Appl. Maths.*, 1957, **15**, 257—262. Naval Research Laboratory, U.S.A. In general, rectilinear flow inside cylindrical tubes of non-circular cross-section is not possible for Rivlin fluids. Consideration is given to special conditions which must be satisfied by such a fluid in order that rectilinear flow may be possible in every cylinder.

5. A rotameter calculation. J. VITOVEC and A. REZABEK, *Coll. Trav. Chim. Tchécosl.*, 1957, **22**, 1699—1703. Research Inst. for Synthetic Rubber, Gottwaldov. Dimensional analysis indicates that the behaviour of a rotameter should be describable by some relation between three definite combinations of the various variables involved. The existence of such a relationship is confirmed experimentally, and a procedure for calibrating the instrument is developed. [Russian]
From the journal summary in German

6. Summarized Proceedings of the eleventh annual conference of the Stress Analysis Group—Leicester, April, 1957. *Brit. J. Appl. Phys.*, 1957, **8**, 467—470. A summary of 15 papers on stress analysis.

7. Theoretical considerations of the viscosity of glass. W. OLDEKOP, *Glastech. Ber.*, 1957, **30**, 8. Earlier attempts to represent the temperature dependence of the viscosity of glasses are discussed. They do not reproduce the course of the viscosity/temperature curve satisfactorily

because the effect of the coupling forces between the ions was neglected. If this coupling is taken into consideration on the basis of Holzmüller's relationship and in conjunction with the breakdown of the glass network with rise in temperature, the experimental results can be reproduced quantitatively. [German] B.C.R.A.

8. Numerical solution of Reynold's equation for sector thrust bearings. B. STERNLICHT and H. J. SNECK, *Lubric. Engng.*, 1957 **13**, 459—463. General Electric Co., Schenectady, N.Y., U.S.A. A speedy, accurate method employing a digital computor has been found which gives results agreeing with experiment and known analytical solutions. If the experimentally determined variable viscosity (due to temperature variations) is taken into account the load-carrying capacity predicted is considerably lower than that predicted by using a constant average viscosity. This is in agreement with field experience. Authors

9. Calculation of the liquid–vapour equilibrium from the viscosity of the liquid phase. V. VANECEK, *Coll. Trav. Chim. Tchécosl.*, 1957, **22**, 1569—1573. Inst. for Chem. Engineering, Tech. High Sch. for Chem., Prague. The author investigates the possibility of calculating, from the viscosity of the liquid phase, the constants in the van Laar equation of third order for binary liquid mixtures. [German] Author

10. The plunger rheometer—Law of flow for a Newtonian liquid. G. S. SMITH, *J. Inst. Petrol*, 1957, **43**, 227—230. Ministry of Supply, Harefield, Middlesex, England. An exact mathematical treatment is given for the flow of a Newtonian liquid in the plunger rheometer.

11. Viscosity of suspensions of uniform spheres. J. HAPPEL, *J. Appl. Phys.*, 1957, **28**, 1288—1291. New York Univ., U.S.A. A mathematical development of the viscosity of suspensions is presented based on the steady-state Stokes–Navier equations of motion omitting inertia terms. The disturbance due to each sphere is assumed to be confined to a frictionless envelope surrounding it similar to the stream tube for flow inside ducts. The relationship obtained between relative viscosity and solids concentration is in good agreement with existing data over a wide concentration range without the necessity of introducing empirical constants. It is thus thought that it may be a suitable model for further theoretical study as well as furnishing a basis for empirical correlation equations of rheological properties. In very dilute systems it does not agree with the well-known Einstein formula, and possible reasons for this variation are advanced. Author

12. Studies in Newtonian flow—V. Further verification of the free space viscosity equation. A. K. DOOLITTLE and D. B. DOOLITTLE, *J. Appl. Phys.*, 1957, **28**, 901—905. Union Carbide Chemicals Co., South Charleston, West Virginia, U.S.A. Values of the limiting specific volume v_0 calculated by a trial-and-error procedure from *n*-alkane viscosity data using the authors' free-space viscosity equation,

$$\ln\eta = B(v_0/v_f) + \ln A,$$

agree substantially with previously published values obtained by extrapolation of density data. Values of v_0 for mercury, sodium, benzene, carbon tetrachloride, dichlorodifluoromethane, and water were calculated by the same trial-and-error procedure. In all cases the free-space equation

VOL.
1
1958

gave a much better fit than the corresponding Andrade temperature equation,

$$\ln\eta = B/T + \ln A.$$

13. The causes responsible for the divergence between the kinetic theory of high elasticity and experience. L. S. PRISS, *Dokl. Akad. Nauk SSSR*, 1957, **116**, No. 2, 225 (via *D.S.I.R. List* No. 108, March 1958). [Russian]

14. A theory of the viscosity of a Maxwellian elastic liquid. M. MOONEY, *Trans. Soc. Rheol.*, 1957, **1**, 63. United States Rubber Co., General Laboratories, Passaic, N.J., U.S.A. Simple Newtonian liquids are assumed to have elastic rigidity and a high rate of stress relaxation, as suggested by Maxwell. It is postulated that in the basic mechanism of flow thermal energy produces a critical volume expansion in a region enclosing several molecules, and as a result the local rigidity and the shear stress are temporarily reduced to zero. The associated local molecular movements constitute a nucleus of stress release and of strain which are transmitted throughout the liquid with the velocity of sound. Many such events, in the aggregate, constitute the viscous flow. The theory, following Debye, treats the molecular thermal vibrations as the sum of elastic ultrahigh-frequency vibrations; and it makes use of Dewey's formula for the mean elastic moduli of an elastic continuum containing small spheres of different elastic moduli. The resulting formula for viscosity involves the adiabatic compressibility, the critical expansion necessary for loss of rigidity, Poisson's ratio, and the degree of molecular association if there is any. Agreement with published experimental data can be obtained with expected or understandable values of the adjustable parameters.

15. A stochastic process model for mechanical breakdown. BERNARD D. COLEMAN, *Trans. Soc. Rheol.*, 1957, **1**, 153. E. I. du Pont de Nemours and Company, Wilmington, Del., U.S.A. A model is developed for discussing the time-dependence of mechanical strength measurements. This model is particularly applicable to polymeric fibres which show large time effects that are not accounted for by the classical "weakest link" theories. Most of the discussion is confined to a perfect fibre, free from flaws, that can be divided into a set of noninteracting slabs. Calculations have been made of the distribution of breaking times for isolated slabs and long fibres composed of many slabs. It is found that, under rather general conditions, the single slab lifetime distribution is asymptotically normal as the number of bonds increases without limit, although the corresponding distribution for a long fibre is never normal. It also appears that, as the cross-sectional area increases, the coefficient of variation of breaking times for a long fibre goes to zero much faster than for a single slab. Toward the end of the article a route is suggested for estimating the effect of stress-concentrating flaws on the distribution of breaking times.

16. On ideal locking materials. WILLIAM PRAGER, *Trans. Soc. Rheol.*, 1957, **1**, 169. Brown University, Providence, R.I. The paper is concerned with the mechanics of ideal locking materials. Such a material deforms freely under negligible stresses until a certain strain invariant reaches a limiting value when locking occurs in the sense that, depending on the locking strain, certain kinds of stress increase will not cause any change in strain. The following boundary value problem is discussed.

A body made of an ideal locking material is subjected to prescribed surface displacements over part of its surface, while the surface tractions are required to vanish over the remainder of the surface ; can the body accommodate itself to these boundary conditions or will the attainment of the prescribed surface displacements be prevented by locking ? Theorems are given which furnish bounds for the surface displacements that cause locking. A simple example is discussed in some detail.

17. Intermolecular forces and the activation energy for viscous flow in liquids. T. H. S. HIGGINS and C. J. G. RAW, *J. Chem. Phys.*, 1957, **27**, No. 3, 623—624. Dept. of Chemistry & Chemical Tech., University of Natal. Discussion of Born–Green theory and calculation of activation energy from intermolecular potential function.

18. New absolute molecular weight method. F. BUECHE and S. W. HARDING, *J. Chem. Phys.*, 1957, **27**, No. 5, 1210 (letter). Physics Dept., University of Wyoming. Method based on shear rate dependence of viscosity of concentrated solutions.

19. Further results on the rubber membrane theory and Laplace's equation. W. FULOP, *J. Sci. Instrum.*, 1957, **34**, 453—454. The small deflexion theory, which assumes constant resultant horizontal tension, fails in the case of coaxial geometry to account at large deflexions for the linear force-deflexion law obtained.

20. Intermolecular forces in quasi-spherical molecules. J. C. MCCOUBREY and N. M. SINGH, *Trans. Farad. Soc.*, 1957, **53**, 877, 883. Dept. of Chem. Engng., Imp. Coll. of Science and Technology, London, England. Measured viscosities of vapours CF_4, SF_6, SiF_4, $C(CH_3)_4$, BF_3 $(CH_2)_3$ in range 20°—180° C have been fitted to several intermolecular potential models.

21. The determination of the elastic field of an ellipsoidal inclusion and related problems. J. D. ESHELBY, *Proc. Roy. Soc. A.*, 1957, **241**, 376—396. Dept. of Physical Metallurgy, Birmingham Univ., England. The author discusses the numerous problems which arise when the uniformity of an elastic medium is disturbed by a region (the " inclusion ") within it which has elastic constants differing from those of the remainder (if, in particular the constants are zero within the inclusion we have the case of a cavity).

22. Studies in collapse analysis of rigid-plastic plates with a square yield diagram. E. H. MANSFIELD, *Proc. Roy. Soc. A.*, 1957, **241**, 311—338. Ministry of Supply, Farnborough, England.

23. On the plastic theory of plates. H. G. HOPKINS, *Proc. Roy. Soc. A.*, 1957, **241**, 153—179. Ministry of Supply, Fort Halstead, England. The paper presents a theory of the small deformations of a thin plate under transverse load ; the plate, which is made of non-hardening rigid-plastic material, obeys the Tresca yield condition and associated flow rule.

24. Folding instability of a layered viscoelastic medium under compression. M. A. BIOT, *Proc. Roy. Soc. A.*, 1957, **242**, 444—454. Shell Development Co. A preliminary theory is established for the stability of a visco-elastic layer sandwiched in an infinitely extended medium of another viscoelastic material when a compressive force is acting in a direction parallel with the layer. A more detailed discussion is given to special

cases such as that of a purely viscous layer in a viscous fluid, an elastic layer in a viscous fluid, a viscous layer in an elastic medium, and of two Maxwell materials.

25. Viscous flow between rotating cylinders and a sheet moving between them. M. R. HOPKINS, *Brit. J. Appl. Phys.*, 1957, **8**, 442—444. Dept. of Physics, Swansea Univ. Coll., Wales. An expression is derived for the thickness of the liquid layer left on the sheet in terms of viscosity of the liquid and the size and speed of the rollers.

26. Action and viscous flow. A. D. MAUDE, *Brit. J. Appl. Phys.*, 1957, **8**, 343—344. Nottingham Technical College, Nottingham, England. A letter discussing the equivalence of viscosity and action per unit volume, proposed by T. V. Starkey.

OL.
1
958

Section B

INSTRUMENTS AND TECHNIQUES

27. A new self-recording rheogoniometer. A. F. H. WARD and P. LORD, *J. Sci. Instrum.*, 1957, **34**, 363—366. Faculty of Technology, Univ. of Manchester, England. A rheogoniometer of cone-and-plate type has been designed. The cone can be used in continuous rotation or S.H.M. Torque, thrust, and applied motion are measured by capacitance gauges and are shown on a c.r.o. to be photographed. The apparatus has proved suitable for the study of polymer solutions.

28. On the calculation of the flow equation (Reibungsgetzes) of plastic substances. W. HEINZ and A. FINCKE, *Kolloidzschr.*, 1957, **154**, 167. Firma Gebr. Haake K.G., Berlin–Dusseldorf. Discussion on methods of obtaining flow equations by means of coaxial cylinder viscometers. [German]

29. A new capillary viscometer. N. N. GREENWOOD and K. WADE, *J. Sci. Instrum.*, 1957, **34**, 288—289. Dept. of Chemistry, Univ. of Nottingham, England. This glass apparatus can be used for unstable, reactive, or volatile liquids, and is robust and simple to operate. It can be used over a wide range of temperatures, and can be completely immersed in a thermostat bath.

30. A viscometer for rapid measurements of dilute polymer solutions at elevated temperatures. R. M. SCHULKEN, JR. and M. L. SPARKS, *J. Polym. Sci.*, 1957, **26**, 227—230 (letter). Research Laboratories, Tennessee Eastman Company, Kingsport, Tennessee, U.S.A. Describes a capillary-type viscometer of new design.

31. Improved rotation viscometer for study of low viscosity liquids at low and intermediate rates of shear. E. H. FREI, D. TREVES and H. EISENBERG, *J. Polym. Sci.*, 1957, **25**, 273—278. The Weizmann Institute of Science, Rehovot, Israel. Describes a concentric cylinder viscometer with electrostatic restoring force. Torque range 0·1—500 dyne cm (to ± 0·2%). Rates of shear 0·1—200 sec.$^{-1}$.

32. Vibrating viscometer for relaxation studies on dilute polymer solutions. B. H. ZIMM, *J. Polym. Sci.*, 1957, **26**, 101—104 (letter). General

Electric Research Laboratories, Schenectady, N.Y., U.S.A. A resonating tube viscometer is described. Frequency range 2—150 kc/sec.

33. Precision viscometry of polyvinyl acetate in toluene. C. A. TUIJNMAN and J. J. HERMANS, *J. Polym. Sci.*, 1957, **25**, 385—401. Laboratorium voor Anorganische en Physiche Chemie, Universiteit, Leiden, Netherlands. Discusses the sources of error in capillary viscometers and illustrates by means of measurements on P.V.A. solutions in toluene.

34. An apparatus for measuring the elastic properties of very soft gels. G. W. SCOTT BLAIR and J. BURNETT, *Lab. Practice*, 1957, **6**, 570—572. Univ. of Reading, England. An apparatus is described which is suitable for measuring the gelation process in soft gels over a range of rigidity moduli from about 10—1000 dynes/cm². Retardation times during the course of gelation can also be measured. Curd made by setting cow's milk with rennet at normal cheese-making concentrations behaves approximately as a Burgers body with a retardation time of about 30 sec. Author

35. A disk rheometer applicable to measuring shortening flow-properties. S. J. LOSKA and E. JASKA, *J. Amer. Oil Chem. Soc.*, 1957, **34**, 495—500. Pillsbury Mills Inc., Minneapolis, Minnesota. This shortening rheometer will measure the relative viscosities of shortenings under a single shear application, the change in shortening viscosity on repeated working, and the relationship of both these properties as a function of temperature.

36. A compressometer for obtaining stress–strain curves of rock specimens. E. R. LEEMAN and C. GROBBELAAR, *J. Sci. Instrum.*, 1957, **34**, 279—280. National Mechanical Engineering Research Institute, Pretoria, South Africa. The apparatus described applies an axial compressive strain, which can be read or recorded continuously up to fracture of the specimen. Wire resistance strain gauges are used, and are designed to be undamaged when fracture occurs.

37. The measurement of Meyer hardness and Young's modulus on the Rockwell Test Machine. D. K. MACKENZIE and T. P. NEWCOMB, *Brit. J. Appl. Phys.*, 1957, **8**, 398—399. Ferodo Ltd., Chapel-en-le-Frith, Stockport, Cheshire. A method is described in which the Rockwell hardness machine is used to determine the Meyer hardness and Young's modulus of a material. Meyer hardness values so derived for a number of materials are compared with those obtained from hardness measurements made on a Vickers hardness machine, and values of Young's modulus compared with figures quoted in standard tables. Author

38. Measurement of elasticity and anelasticity of small discs by an inductor method. G. BRADFIELD and F. A. LEVI, *Brit. J. Appl. Phys.*, 1958, **9**, 13—16. National Physical Laboratory, Teddington, Middlesex. An instrument is described operating on the inductor principle to set a small disc into radial vibration so that one of its elastic constants can be determined from its frequencies of resonance. The method of testing also permits the internal function to be measured as the ratio of the real to the imaginary component of the elastic compliance.

39. High temperature tensometry and its application to amorphous polyethylene terephthalate. E. L. FOSTER and H. HEAP, *Brit. J. Appl. Phys.*, 1957, **8**, 400—402. I.C.I. Ltd., Harrogate, Yorks. An apparatus

is described in which the material is heated for not more than one second before the application of a strain. The effects of both temperature and straining rate on the shape of the stress–strain curve of polyethylene terephthalate have been investigated and the results indicate that the crystallisation is stress controlled. The application of the results to the fibre spinning and drawing processes is discussed.

40. Sonic methods for the determination of mechanical properties of solid materials. C. E. KESLER and T. S. CHANG, *A.S.T.M. Bulletin*, No. 225, 40—45, Oct. 57. University of Illinois. Discusses methods based on resonance of specimens and propagation of waves. Thirty-nine refs.

41. Evaluation of tests for forgeability. A. B. DRAPER, *A.S.T.M. Bulletin*, No. 223, July 1957, 62—68. Syracuse University Research Institute. Review of laboratory forgeability tests and consideration of factors influencing results (strain rate, friction, ductility). Thirty-five refs.

42. The Vicat softening point test for plastics. C. E. STEPHENSON and A. H. WILLBOURN, *A.S.T.M. Bulletin*, No. 224, Sept. 1957, 28—31. I.C.I. Plastics, Welwyn Garden City. Description of the Vicat-needle softening point test as modified for testing thermoplastics. Six refs.

43. Low temperature brittleness testing of polythene. E. A. W. HOFF and S. TURNER, *A.S.T.M. Bulletin*, No. 225, Oct. 1957, 58—64. I.C.I. Plastics, Welwyn Garden City, A standard brittle point test (A.S.T.M. D746) gives results which depend markedly on method of specimen preparation. The failure mechanism is discussed.

44. Spiral flow moulding. L. GRIFFITHS, *Mod. Plast.*, Aug. 1957, 111—115. I.C.I. Plastics, Welwyn Garden City. Uses a mould with a long spiral channel to assess injection moulding behaviour of thermoplastics.

45. Retardation of staling rate of bread by means of temperature increase. H. STEPHAN, *Brot. u. Gebäck*, 1957, **11**, 215—221. Arbeitsgemeinschaft Getreideforschung, Detmold, am Schützenberg, 9, Western Germany. An instrument, a panimeter, is described by means of which crumb resistance to compression and elasticity is graphically recorded. [German]

46. New aspects of the evaluation of biscuit flour. G. CLEWLOW and W. DIXON, *J. Sci. Fd. Agric.*, 1957, **8**, 541—547. Wallace & Tiernan Ltd., Power Road, London, W.4, England. Two simple empirical instruments are described by means of which tests (The Specific Recovery Test and the Water Tolerance Test) on soft wheat flour doughs are performed.

47. The determination of the water absorption of flour by means of a penetrometer. E. MAES, *Brot u. Gebäck*, 1957, **11**, 187—189. Centraal Laboratorium, Ministerie Van Evonomische Zaken, Antwerpen, Belgium. The hemispherical end of a needle is allowed to press into the dough under a constant load for a definite time. All moving parts of the instruments have been replaced by electromagnets wherever possible. The results obtained are in close agreement to those determined by means of the Brabender Farinograph. The penetrometer construction has been kept simple to make it available at an estimated price of 300 D.M. only. [German]

48. Measuring stress relaxation in starch gels. C. O. CHICHESTER and C. STERLING, *Cereal Chem.*, 1957, **34**, 233—237. Dept. of Food Technology, Univ. of California, Davis, California, U.S.A. An apparatus is described for recording continuously the relaxation of stress in starch gels under compression. The apparatus permits the selection of varying amounts of deformation to be imposed on the sample. Stress is developed in strain gauges, which are mounted on a steel cantilever beam. A potential, modified in the deformed strain gauges, is applied to a millivolt recorder. The linear relationship between beam deformation and gauge output permits a direct chronological record of relaxation of stress in the gel.

49. The effect of bowl speed upon amylogram curve characteristics. S. J. LOSKA, JR., *Cereal Chem.*, 1957, **34**, 305—311. Pillsbury Mills, Inc., Minneapolis, Minnesota, U.S.A. The effect of rotational speed of the bowl from 40 to 70 r.p.m. on the maximum viscosity of amylograph curves was studied, using a hard winter wheat flour containing two increments of malted barley flour, and a non-malted soft wheat patent flour. The change in amylogram peak height was essentially linear with bowl speed. The slope of the bowl speed-amylogram peak value line decreased with malt flour addition. Below 60 r.p.m. the peak values fell below the linear relationship due to the settling of material at the bottom of the bowl. The shape of the curve beyond the peak viscosities indicated that the breakdown angle is a function of bowl speed and malt flour level. No apparent change in breakdown angle occurred with the cake flour suspension upon increasing the bowl speed.

50. Recording apparatus for measuring some mixing characteristics of flour-water batters. R. A. ANDERSON and E. B. LANCASTER, *Cereal Chem.*, 1957, **34**, 379—388. Northern Utilization Research and Development Div., Agric. Research Service, U.S. Dept. of Agric., Peoria, Illinois, U.S.A. A recording apparatus for determining some mixing characteristics of flour-water batters has been developed and constructed. The apparatus continuously measures and records the power required to mix the batter while it is being prepared. The mixing curves show that the over-all stiffness of a batter increases, with an increase in the protein content of the flour, and with a decrease in the water-to-flour ratio.

51. A fixed point of viscosity in the working-range of glasses : rapid determination of the viscosity–temperature curve. A. DIETZEL and R. BRÜCKNER, *Glastech. Ber.*, 1957, **30**, No. 3, 73. Determination of viscosity by measurement of the rate of fall of Pt-Rh rods under their own weight and the definition of a " sinking point " as a fixed point at a viscosity of 10^4 poises. Determination of the complete course of the viscosity/temperature curve for orientation purposes from the transformation point, the Littleton point and the sinking-point by the aid of the Fulcher-Tammann equation. Examples of the rapid determination of viscosity curves with glasses of very different compositions. B.C.R.A.

52. Survey of the effect of composition on the internal friction of glass. L. C. HOFFMAN and W. A. WEYL, *Glass Ind.*, 1957, **38**, 81. Glass rods were caused to twist by incorporation in the vertical member of a torsion pendulum, and the damping of the pendulum was observed as a function of temperature. B.C.R.A.

53. Cone-plate viscometer. Comparison with coaxial cylinder viscometer. R. McKENNELL, *Analyt. Chem.*, 1956, **28**, 1710. The cone-plate viscometer provides a rapid means of obtaining reproducible flow measurements on non-Newtonian fluids by subjecting the sample to definite uniform shear rates. The conventional coaxial-cylinder viscometer suffers the disadvantages of shear rate variation across the measuring annulus, end effects, limited range of operation, and filling, cleaning, and centring difficulties. The cone-plate configuration provides constant shear conditions without introducing constructional complexity. In practice, filling, cleaning, and temperature stabilization can be completed in about 30 sec. The flow-curve recorder is capable of plotting a curve in 15 sec. with uniform shear acceleration. B.C.R.A.

54. Viscosity measurement by the rotating-cylinder method. M. WATANABE and R. KOYAMA, *J. Ceram. Ass. Japan*, 1956, **64**, 263. [In Japanese] B.C.R.A.

54a. A sensitive electronic strain gauge. H. L. ALLSOPP and D. F. GIBBS, *J. Sci. Instrum.*, 1957, **34**, 308—311. H. H. Wills Physics Lab., Univ. of Bristol, England. This gauge only responds faithfully to fairly rapid displacements, and its limit of sensitivity is *c.* 10^{-7} cm. The apparatus is normally used dynamically. The specimen temperature can be controlled between $-150°$ and $+200°$ C. This gauge has been used to investigate the electromechanical properties of ferro-electric barium titanate.

55. Production rate in three-roll mills. J. H. TAYLOR, JR. and A. C. ZETTLEMOYER, *Paint Manuf.*, 1957, **27**, No. 8, 299—304, 319. National Printing Ink Research Institute, Lehigh University, Bethlehem, Pa., U.S.A. Expressions are given for assessing operative efficiency of a paint mill.

Section C

METALS AND OTHER SOLIDS

56. The plotting of strain–hysteresis loops. W. H. COGILL, *J. Sci. Instrum.*, 1957, **34**, 396—398. Dept. of Mech. Engng., Leeds Univ., England. The difficulty of measuring small departures from linearity in the extension of steel specimens by cyclic tensile loading has been overcome by comparison with a known specimen. Measurements were made by means of a bridge circuit. With stresses confined to the normal working range, the accuracy of the hysteresis loop obtained is 4%.

57. The influence of the degree of deformation on the formation of cracks. YU. S. ZUEV *et al.*, *Dokl. Akad. Nauk SSSR*, 1957, **116**, No. 5, 813 (Lia *D.S.I.R. List* No. 118, March 1958). [Russian]

58. Lubicated friction under severe conditions. J. POMEY, *Rev. de l'Inst. franç. du pétrole*, 1957, **12**, 754—780, 887—914. Régie nationale des Usines Renault, France. A very detailed report giving theoretical treatments and experimental results for many aspects of the cause and alleviation of friction and wear. In particular, Blok's concept of a critical

seizure temperature is discussed and equations are developed for the thermal conditions in the 4-ball machine. Attention is given to the modes of action of such remedies as physical and chemical pre-treatment of the metal surfaces and lubricant additives. [French]

59. Friction as resistance to shear of thin surface layers of solids. G. I. EPIFANOV, *Dokl. Akad. Nauk SSSR*, 1957, **114**, 764—767. [Russian]

60. Transition temperature for surface damage in sliding metallic contact. L. F. COFFIN, JR., *Lubric. Engng.*, 1957, **13**, 399—405. General Electric Co., Schenectady, N.Y., U.S.A.

61. Strain aging hydrogen embrittlement in alpha–beta titanium alloys. HARRIS M. BURTE, *Trans. Soc. Rheol.*, 1957, **1**, 119. Materials Laboratory, Directorate of Research, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. Hydrogen contamination in the alpha–beta class of titanium alloys leads to a very pronounced strain rate sensitivity of the ductility of these materials, and to low stress, premature fracture under sustained tensile loading (creep). The effects of strain rate, hydrogen concentration, temperature, stress concentrations, alloy composition, and microstructure are described. A mechanism for this strain aging embrittlement is suggested which involves plastic deformation inducing microsegregation of interstitially dissolved hydrogen to the grain boundaries of these two-phase polycrystalline materials. This microsegregation involves diffusion of the hydrogen and proceeds at a finite rate. Properties measured under various conditions of loading depend upon whether the rate of deformation is fast or slow relative to the rate of microsegregation and consequent embrittlement.

62. Softening of steels by cold-working. P. CHOLLET and H. P. TARDIF, *Nature, Lond.*, 1957, **180**, 754—755. Experiments on work softening of three steels suggest that the observed effect (of softening) in quenched and tempered steels after deformation may not be a function of the presence of internal stresses only. Other factors are suggested.

63. Laws governing the drawing of metals in the presence of lubricants. S. J. VEILER and V. I. LICHTMAN, *Dokl. Akad. Nauk SSSR*, 1957, **114**, 1224—1227. [Russian]

64. Elastic Properties of glass. E. K. KELLER *et al.*, *Dokl. Akad. Nauk SSSR*, 1957, **116**, No. 2, 221 (Lia *D.S.I.R. List* No. 108, March 1958). [Russian]

65. Stabilization of the viscosity of glass in its transition region. M. WATANABE and R. KOYAMA, *J. Ceram. Ass. Japan*, 1956, **64**, 223. Change of viscosity of glass with time at constant temperature was analysed by application of the network temperature concept. Annealing and other problems relating to viscosity are discussed on the basis of an equation representing the first approximation of the network temperature ; a second equation is derived by integration of the first, and a third equation was derived, involving the time at which the viscosity value reaches its equilibrium value (t_s). A t_s-curve is plotted. Conclusions were inferred by combining the concept of network temperature and t_s-curve. [Japanese]

B.C.R.A.

66. Viscous flow in glass to metal seals. H. E. HAGY and H. N. RITLAND, *J. Amer. Ceram. Soc.*, 1957, **40**, 58. Birefringence measurements were made on seals with simple geometries during cooling at various rates. Thermal-contraction results were also obtained on the metal and on the glass while cooling at the same rates, and the viscosity of the glass during cooling at a constant rate was calculated. B.C.R.A.

67. Viscosity of fused glasses as a function of the temperature. J. CORNELISSEN, J. VAN LEEUWEN, and H. I. WATERMAN, *Chim. et Industr.*, 1957, **77**, 69. The equation $\log \nu = A/T^x + B$, where ν is the kinematic viscosity, T is the temperature in °K, and A, B, and x are constants, is used in applying the physical constants given in the literature for fired glasses consisting of SiO_2+Li_2O, SiO_2+Na_2O, and SiO_2+K_2O. Results show its validity. [French] B.C.R.A.

OL.
1
958

68. Structure of glass, heat treatment and viscosity. E. PLUMAT, *Silicates Industr.*, 1956, **21**, 391—396, 447—457. Accurate viscosity measurements on silicate glasses prove that the activation energy of the viscous flow and the lattice constant do not vary continuously with temperature but by jumps. Discrete changes in the flow constants at some critical temperatures are interpreted by accepting the existence of ionic associations in glasses ; the mean size of these associations, and their statistical composition vary by jumps. Certain other properties, other than the viscosities, appear to support this approach. [French] B.C.R.A.

69. Viscosity of glasses in the transformation-range. M. PROD'HOMME *Verres et Réfr.*, 1956, **10**, 208. The Chevenard dilatometer was used to determine, at various temperatures, the viscosity of ordinary glass, As_2S_3 glass, As_2Se_3 glass, glycerine glass. The results show that the temperatures of the transformation-range as defined by the temperatures at which the physical properties (e.g. expansion, R.I., specific heat) show an abrupt variation always correspond to the same viscosity values, about 10^{12} poises. It is deduced that the viscosity η is a constant, truly characteristic of the vitreous state, permitting a demarcation of the transformation-range in which $\log \eta$ varies almost linearly with temperature. B.C.R.A.

70. The non-elastic behaviour of glass on impact. P. L. KIRBY, *Verres et Réfr.*, 1956, **10**, 201. "Rebound resilience" is defined and measurements of it for glasses subjected to the impact of a small steel ball (cold) between 0° to 1000° are described. [French] B.C.R.A.

71. Two peaks in the internal friction as a function of temperature in some soda silicate glasses. K. E. FORRY, *J. Amer. Ceram. Soc.*, 1957, **40**, 90. Measurements of the internal friction of the glasses 17% Na_2O–83% SiO_2, 25.6% Na_2O–74.4% SiO_2, and 34% Na_2O–66% SiO_2 were made as a function of temperature, composition, and frequency in the range 1 to 3 c/s and from 32.2° to 260°. The internal friction as a function of temperature revealed two distinct peaks for each glass tested. One peak occurred in the temperature range −46° to +10° and the other in the range 149° to 260°. All the observed peaks were found to be best represented by an assumed Gaussian distribution of heats of activation with the high-temperature peaks exhibiting a much wider distribution than the low-temperature peaks. It was therefore concluded that none of the peaks was a manifestation of a single heat of activation. The

temperatures at which all peaks occurred increased with increasing frequency. From this shift of " peak " temperatures with frequency, the most likely heats of activation associated with each peak were calculated. The temperature dependence of the dynamic shear modulus for each glass was used to calculate the " relaxation strength " of the relaxation process for each peak. Analysis strongly indicated that the high-temperature peaks as well as the low-temperature ones were related to co-operative action among sodium. B.C.R.A.

72. Structural-mechanical properties of plastic ceramic bodies. S. P. NICHIPORENKO, *Dopov. Akad. Nauk Ukr. SSR*, 1956, 267 : from *Chem. Abstr.*, 1957, **51**, 1567. Nine samples of clay were investigated. Elasticity and amount of residual tension (stress) P_L of the elastic deformation appear the most important characteristics of the clays for the shaping and drying of bodies. The length of the process of true relaxation may lead in the articles to the creation of a residual form stress, which becomes established and even increased by the thixotropic hardening of the mass in the early stages of drying. As a function of the nature of the clays, deformation and relaxation properties of the mass with change of humidity can change in various manners, which are connected with processing and shaping. Magnitude of the conventional force of deformation is proposed as a criterion of plastic ceramic bodies. [Russian summary]

B.C.R.A.

73. Cement grouts with good plugging properties. N. I. TITKOV and A. I. BEREZHNOI, *Neftyanoe Khoz.*, 1957, 13. [Russian] (From D.S.I.R. Translated Contents List No. 103, Oct. 1957.)

74. Strength of highly porous brittle materials. K. SCHILLER, *Nature, Lond.*, 1957, **180**, 862—863. Research Dept., British Plaster Board (Holdings) Ltd., East Leake, Leics., England. A formula relating the measured strength to the porosity has been obtained. Plaster of Paris from various sources was used under different conditions to verify the formula.

75. A loading system for creep studies of concrete. C. H. BEST, D. PIRTZ, and M. POLIVKA, *A.S.T.M. Bulletin*, No. 224, Sept. 1957, 44—47. University of California. Uses hydraulic loading cells for 6-in. diameter columns. Nine refs.

Section D

POLYMERS, ELASTOMERS AND VISCOELASTIC MATERIALS

76. Applicability of Stoke's equation to macromolecules. J. T. EDWARD, *J. Polym. Sci.*, 1957, **35**, 483—485 (letter). Chemistry Department, McGill University, Montreal 2, Canada.

77. Filler reinforcement of silicone rubber. A. M. BUECHE, *J. Polym. Sci.*, 1957, **25**, 139—149. General Electric Research Laboratories, Schenectady, N.Y., U.S.A. Measurements of swelling and modulus of silicone rubbers compounded with five different fillers are reported. The results are compared with a modified form of the kinetic theory of elasticity.

78. Mechanical properties of natural and synthetic rubbers. F. BUECHE, *J. Polym. Sci.*, 1957, **25**, 304—324. Department of Physics, University of Wyoming, Laramie, Wyoming, U.S.A. The tensile creep behaviour, for strains up to 5%, is reported for a number of rubbers over a range of temperatures.

79. Cross-linking of oriented rubber. A. CHARLESBY and E. VON ARNIM, *J. Polym. Sci.*, 1957, **25**, 151—158. Tube Investments Research Laboratories, Hinxton Hall, Cambridge, England. Rubber samples which were cross-linked by radiation in the oriented state were found to show anisotropic elastic properties. This is discussed in terms of chain fracture and stress relaxation occurring during cross-linking.

80. The influence of rubber on the brittleness and viscosity of bituminous materials. P. MASON, E. N. THROWER, and L. M. SMITH, *J. Appl. Chem.*, 1957, **7**, 451—459. B.R.P.R.A., Welwyn Garden City, England. Admixture of rubber with bitumen increases hardness and decreases brittleness. Tensile tests at 0° C and viscosity at 25° C (for bitumens) and 45° C (sand asphalts) were carried out. Seventeen refs.

81. Internal flaws in bonded cylinders of soft vulcanized rubber. A. N. GENT and P. B. LINDLEY, *Nature, Lond.*, 1957, **180**, 912—913. B.R.P.R.A., Welwyn Garden City, Herts., England. Internal cracks have been found after subjecting rubber to tensile loads, and their cause is ascribed to a negative "hydrostatic" pressure.

82. Effect of gamma radiation on rubber solutions. G. I. FINCH, S. DAS GUPTA, and A. K. DAS GUPTA, *J. Sci. Industr. Res.*, 1957, **16B**, 328—330. National Chemical Laboratory, Poona, India. Solutions of crêpe rubber in several solvents were exposed to γ-radiation. Changes in colour, viscosity, and infra-red adsorption only occurred in CCl_4 solutions. Cyclization was observed in the final irradiated product.

83. Influence of ion exchange on size and shape of chain-like polyelectrolyte molecules. R. E. COOPER and A. WASSERMANN, *Nature, Lond.*, 1957, **180**, 1072. University College, Gower Street, London, W.C.1, England. In this brief report on sodium and magnesium alginates, the viscosities of buffered and unbuffered aqueous solutions were measured with Flory and Couette viscometers at 25° C. The rate of shear was varied between 0·4 to 2500 sec^{-1}.

84. Sound velocity and damping in Ziegler polythene. E. BUTTA, *J. Polym. Sci.*, 1957, **25**, 239—242 (letter). Instituto di Chimica Industriale ed Applicata, Universita di Pisa, Pisa, Italy. Results of measurements on Ziegler polythenes and commercial polythenes are presented and compared.

85. The flow properties of polythene and their effect on fabrication. P. L. CLEGG, *Brit. Plast.*, Dec. 1957, 535—537. Imperial Chemical Industries Ltd., Plastics Div., Welwyn Garden City, Herts., England. Onset of roughness and waviness in extruded rods in relation to flow curve. Full text to be published in Plastics Institute Transactions.

86. Capillary flow of molten polyethylene—a photographic study of melt fracture. J. P. TORDELLA, *Trans. Soc. Rheol.*, 1957, **1**, 203. Polychemicals Department, E. I. du Pont de Nemours & Company, Inc., du Pont Experimental Station, Wilmington, Del., U.S.A.

87. Polyethylene : preparation, structure and properties. S. L. AGGARWAL and O. J. SWEETING, *Chem. Rev.*, 1957, **57**, 665—742. Central Research Dept., Olin Mathieson Chemical Corpn., New Haven 4, Connecticut, U.S.A. This review contains a section on the rheological properties of molten polyethylene. The relation between these and its structure and molecular weight are discussed. Further brief reference is made to melt and solution viscosities, stress–strain curves, elastic moduli, stress birefringence, creep, and relaxation times.

88. On the computation of the photoelastic coefficient for polymers. YU. J. GOTLIB, *Dokl. Akad. Nauk SSSR*, 1957, **114**, 57—60. [Russian]

89. Photoelastic properties of polystyrene in the glassy state—I. Effect of molecular orientation. R. D. ANDREWS and J. F. RUDD, *J. Appl. Phys.*, 1957, **28**, 1091—1095. Dow Chemical Co., Midland, Mich., U.S.A. The effect of molecular orientation on the stress-optical coefficient at room temperature (24° C) was measured using polystyrene monofilaments with different degrees of orientation. High degrees of orientation were obtained by cold-stretching. The optical measurements were made using a polarizing microscope fitted with a Senarmont compensator. The stress-optical coefficient shows a strong dependence on molecular orientation, using birefringence as the index of molecular orientation. The stress-optical coefficient appears to decrease linearly vs. birefringence, from a value of about +10 brewsters at zero birefringence to a value of about +4 brewsters at −0.04 birefringence. The elastic (Young's) modulus was also measured (in tension) as a function of orientation, and was found to increase nonlinearly with orientation (from 4.3×10^5 psi at zero birefringence to 6.1×10^5 psi at −0.04). A curve of strain-optical coefficient vs. orientation was obtained by multiplying stress-optical and modulus values ; this decreases nonlinearly and to a somewhat lesser extent than the stress-optical curve (from about +0.03 at zero birefringence to +0.017 at −0.04). The significance of these constants in photoelastic experiments is discussed. Author

90. Photoelastic properties of polystyrene in the glassy state—II. Effect of temperature. J. F. RUDD and E. F. GURNEE, *J. Appl. Phys.*, 1957, **28**, 1096—1100. Dow Chemical Co., Midland, Michigan, U.S.A. The effect of temperature on the stress-optical coefficient of polystyrene was measured at twelve different temperatures from −195° to +24°C using samples of unoriented polystyrene sheet. The stress-optical coefficient appears to decrease with temperature from a value of about +17 brewsters at −195° C to a value of about +10 brewsters at room temperature using a flexural technique and was found to decrease linearly with temperature from 6.36×10^5 psi at −198° to 4.65×10^5 psi at + 24°C. A curve of strain-optical coefficient vs. temperature was obtained by multiplying stress-optical and modulus values ; this curve increases with decreasing temperature from about +0.03 at +24° to +0.073 at −195° C. Author

91. Flow birefringence and stress—V. Correlation of recoverable shear strains with other rheological properties. W. PHILIPPOFF, F. H. GASKINS and J. G. BRODNYAN, *J. Appl. Phys.*, 1957, **28**, 1118—1123. Franklin Institute, Philadelphia, 3, Pa., U.S.A. The correlation of normal stress with the shear stress and flow birefringence of flowing solutions has been extended to include the recoverable shear strains which can be measured directly by a rotational viscometer in " recoil ". This has been shown

experimentally with solutions of a high-viscosity nitro-cellulose in *n*-butyl acetate and a viscous polyisobutylene. These results show that the principal axes of the tensors of stress, strain and optical anistropy coincide, even when no constant shear modulus (shear compliance) exists.

Author

92. An investigation of the formation of regenerated cellulose filaments from viscose. (Second communication.) H. KLARE and A. GROBE, *Faserforschung*, 1957, **8**, 348—354. Deutsche Akademie der Wissenschaft zu Berlin, Institut für Faserstoff-Forschung in Teltow-Seehof. The authors have previously reported (*ibid.*, 1955, **6**, 97) investigations of the increase of filament diameter observed when viscose is extruded. The present paper deals with the effect of using different solutions in the bath into which the filaments are spun. [German]

93. Investigations of the influence of the average degree of polymerisation and the concentration of cellulose in the viscose on some physical properties of regenerated cellulose fibres. (Second communication.) H. KLARE, *Faserforschung*, 1957, **8**, 262—266. Deutsche Akademie der Wissenschaft zu Berlin, Institut für Faserstoff-Forschung in Teltow-Seehof. The tensile strength of regenerated cellulose fibres depends markedly on the average degree of polymerisation (D.P.) and on the concentration of cellulose in the viscose. As this concentration is increased from 5%, the strength increases rapidly and passes through a maximum near 7% concentration. The value of the strength at the maximum increases with increasing D.P. but the concentration at which the maximum occurs is almost independent of D.P. [German]

94. Relation of intrinsic viscosity to cellulose chain length. W. J. ALEXANDER, O. GOLDSCHMID and R. L. MITCHELL, *Ind. Eng. Chem.*, 1957, **49**, 1303—1306. Rayonier, Inc., Shelton, Wash., U.S.A. The intrinsic viscosity of a number of cellulose derivatives has been measured, and has been related to the degree of polymerisation by way of the nitrate D.P.

95. False viscosity in cellulose acetate solutions. G. A. RICHTER and L. E. HERDLE, *Ind. Eng. Chem.*, 1957, **49**, 1451—1452. Eastman Kodak Co., Rochester, N.Y. The difference between the intrinsic viscosities of solutions in acetone of acetates prepared from wood cellulose and cotton linters is discussed.

96. On the viscometric behaviour of polycaproamide solutions in concentrated sulphuric acid—II. W. DAWYDOFF, *Faserforschung*, 1957, **8**, 267—274. Leuna-Werke " Walter Ulbricht ". The viscosities of dilute solutions of polyamides in concentrated sulphuric acid are determined at various concentrations and temperatures, using an Ubbehohde viscometer. In certain conditions, an increase of temperature results in an increase of the relative viscosity (solution viscosity/solvent viscosity). [German]

97. Empirical relationships between the flow curves of high molecular solutions and the properties of dissolved molecules—I. J. SCHURZ, *Kolloidzschr.*, 1957, **154**, 97. Institut fur physikalische Chemie der Universitat Graz, Austria. Introduction giving methods and materials for measurements on viscose, cellulose nitrate and carboxymethyl cellulose using the Umstätter structure viscometer (efflux-capillary). [German]

98. Reactions of unsaturated fatty alcohols—III. Viscosity and molecular weight studies on some vinyl ether polymers. L. E. GAST, W. J. SCHNEIDER, and H. M. TEETER, *J. Amer. Oil Chem. Soc.*, 1957, **34**, 307—310. U.S. Dept. of Agriculture, Peoria, Illinois, U.S.A. It is shown that logarithmic plots of molecular weight vs. intrinsic viscosity gave linear relationships for stearyl, soyabean and linseed polymers.

99. Alkyd advances. [**Thixotropic alkyds.**] D. M. JAMES, *Paint Manuf.*, 1957, **27**, No. 11, 401—403, 415. Developments in thixotropic alkyds that have reached the production stage in this country are considered. Thixotropy in such polyamide-modified alkyd resins is dependent on the amount of the polyamide and also on the reaction time. The essentially new feature is the extended and variable time scale of thixotropy. Measurements with the thin film viscometer made by Mell and Ford are referred to. Fourteen refs.

100. [**Measurement of surface tackiness of rubber compositions.**] PICKUP, *Paint Manuf.*, 1957, **27**, No. 8, 320 (from *Trans. Inst. Rubber Ind.*, 1957, **33**, (2), 58). The device used is particularly intended for studying variations in tack over a given area, under production conditions.

101. On the flow mechanism of polyvinyl alcohol. V. A. KARGIN and T. I. SOGOLOVA, *Zh. fiz. hem.*, 1957, **31**, No. 6, 1328 (via *D.S.I.R. List* No. 118, March 1958). [Russian]

102. The thermal incline : a means of measuring viscosities of plastisols at elevated temperatures. E. T. SEVERS and J. M. AUSTIN, *Trans. Soc. Rheol.*, 1957, **1**, 191. Bakelite Fellowship, Mellon Institute, Pittsburgh, Pa., U.S.A. The thermal incline is an inclined plane with a thermal gradient perpendicular to the line of flow, enabling a continuous measurement of fluidity through a wide range of temperatures. Data are presented showing the effect of formulation on the flow of vinyl chloride resin plastisols and how these data may be used to predict the temperature of minimum coating weight of dipped objects. Viscosities of a Ucon (polyalkylene glycol) lubricant obtained using the thermal incline agree reasonably well with viscosities obtained from capillary viscometer data.

103. Factors affecting plastisol flow. H. E. FREY, *Mod. Plast.*, Dec. 1957, 164—166, 171—172. Central Res. Dept., The General Tire & Rubber Co., Akron, Ohio, U.S.A. Shear stress/rate of shear curves of vinyl resin plastisols were studied using a Brookfield viscometer and Severs–Austin extrusion rheometer. Factors affecting the flow curve are : size distribution of polymer particles, mixing procedures, and surface active agents, pigments, etc.

104. Heat generation and conduction in the flow of a viscous compressible liquid. H. L. TOOR, *Trans. Soc. Rheol.*, 1957, **1**, 177. Chemical Engineering Department, Carnegie Institute of Technology, Pittsburgh 13, Pa., U.S.A. The energy equation has been solved for the case of a compressible non-Newtonian liquid entering a tube at temperature equal to the wall temperature. It is shown that the temperature in the centre of the tube initially decreases with distance due to expansion of the liquid while away from the centre it increases with distance due to frictional heat generation. For most polymers the heat generation eventually predominates and at some distance along the tube the centre line temperature

begins to rise. The increase continues until the steady temperature profile is reached. A simple equation is presented which gives the distance required to closely approach the steady profile, and two different methods for obtaining rheological data are considered.

105. On normal stresses, flow curves, flow birefringence, and normal stresses of polyisobutylene solutions—I. Fundamental principles. W. PHILIPPOFF, *Trans. Soc. Rheol.*, 1957, **1**, 95. The Franklin Institute Laboratories for Research and Development, Philadelphia 3, Pa., U.S.A.

106. On normal stresses, flow curves, flow birefringence, and normal stresses of polyisobutylene solutions—II. Experimental. JOHN G. BRODNYAN, F. H. GASKINS, and W. PHILIPPOFF, *Trans. Soc. Rheol.*, 1957, **1**, 109. The Franklin Institute Laboratories for Research and Development, Philadelphia 3, Pa., U.S.A. A mathematical analysis of the existing theories of normal stresses is made. It can be shown that they all give identical results and are based on the same three basic assumptions when one discusses large elastic deformations. Experiments in a wide range of variables showed that the normal stresses disappear as soon as the viscosity becomes constant at low rates of shear. The proportionality between the degree of birefringence and the difference of the principal stresses could be confirmed in three decades of variables. "Hooke's law in shear" could be proved up to about a shear of 20.

107. Normal stress effect in polyisobutylene solutions—I. Measurements in a cone and plate instrument. HERSHEL MARKOVITZ and R. BRADY WILLIAMSON, *Trans. Soc. Rheol.*, 1957, **1**, 25. Mellon Institute, Pittsburgh 13, Pa., U.S.A. Normal stress measurements have been made on concentrated solutions of an unfractionated polyisobutylene in Decalin in an apparatus with a cone and plate geometry. Data taken at various concentrations and temperatures can be superposed in a way similar to that used for the dynamic rigidity. The functional relationship between the normal stress and rate of shear is related to that between the dynamic rigidity and the frequency. The results are discussed in terms of the recent rheological theories of DeWitt and Rivlin.

108. Normal stress effect in polyisobutylene solutions—II. Classification and application of rheological theories. HERSHEL MARKOVITZ, *Trans. Soc. Rheol.*, 1957, **1**, 37. Mellon Institute, Pittsburgh 13, Pa., U.S.A. Many rheological theories can be summarized in terms of a dependence on the rate of shear of the deviatoric components of the normal stresses. In such cases two functions of the rate of shear, at most, are needed to characterize the normal stress effect. In some theories these two functions are simply related. A basis for classification of these rheological theories is thus provided. These classes of theories are applied to the cases of shearing between a cone and plate, two parallel circular discs, and coaxial cylinders. Cone and plate data give directly one of the normal stress functions. Coaxial cylinder data are especially useful in obtaining the other function and distinguishing among the theories. The available normal stress data on polyisobutylene solutions are examined and found to favour one of the types of theories. The coaxial cylinder data are analyzed without using a Newtonian approximation with the help of the known flow curve for these solutions. Evidence for a reduced variable treatment of normal stress data is presented. The relationship of normal stress and dynamic rigidity data is discussed.

109. Rubberised bituminous materials and their use in road construction. W. D. PARKER and W. D. C. WALKER, *J. Appl. Chem.*, 1957, **7**, 481—491. Winn & Coales Ltd., Chapel Road, London, S.E.27, England. Penetration/temperature characteristics and brittle point tests are described for coal tar pitches and bitumens modified with synthetic rubbers and polymers such as polyvinyl chloride.

110. Creep of glass reinforced plastics. S. GOLDFEIN, *A.S.T.M. Bulletin*, No. 225, Oct. 1957, 29—36. Fort Belvoir, Virginia, U.S.A. An empirical method of extrapolating creep properties from short-time tests. Thirteen refs.

111. Static friction of bulk polymers over a temperature range. B. L. REES, *Research*, 1957, **10**, 331—332 (letter). British Nylon Spinners Ltd., Pontypool, England. Static friction at temperatures up to 200° C for nylon 6 nylon 6-6 nylon 6-10 teflon and polyethylene.

112. Measuring temperature dependence of mechanical properties of plastics. KATSUHIKO ITO, *Mod. Plast.*, Nov. 1957, 167—172. Div. of Engineering, Brown University, R.I., U.S.A. Use of a Rockwell hardness machine on small test specimens at elevated temperatures.

113. Mechanical resonance dispersion in crystalline polymers at audio frequencies. E. R. FITZGERALD, *J. Chem. Phys.*, 1957, **27**, No. 5, 1180—1193. Dept. of Physics, Pennsylvania State Univ., U.S.A. Measurement of complex shear compliance for polytetrafluorethylene, linear polyethylene, and polyvinyl stearate revealed multiple frequency dispersions of the " resonance " type, which differ from the usual relaxation dispersions found in polymer systems.

114. Anomalous behaviour of polymer solutions—I. Non-Newtonian behaviour of polyvinyl acetate solutions. S. L. KAPUR and S. GUNDIAH, *J. Polym. Sci.*, 1957, **26**, 89—93. National Chemical Laboratory of India, Poona 8, India. Experimental investigation of viscosity of dilute solutions of polyvinyl acetate fractions in benzene at different rates of shear and two temperatures.

115. On the non-Newtonian viscosity of dilute polymer solutions. R. CERF, *J. Polym. Sci.*, 1957, **25**, 247—250 (letter). Centre de Recherches sur les Macromolecules, 6 rue Boussingault, Strasbourg, France. Compares Copic's experimental results with Cerf's theory of dilute polymer solutions.

116. Dependence of mechanical shear degradation of polymers in solution on rate of energy application and on concentration. P. GOODMAN, *J. Polym. Sci.*, 1957, **24**, 325—331. National Bureau of Standards, Washington D.C., U.S.A. Presents measurements on the degradation of solutions of polyisobutylene in cetane due to shearing in a capillary tube.

117. An experimental investigation of highly elastic polymer specimens for relation between the rate of their rupture process and rate of deformation. V. E. GUL and G. P. KRUTETSKAYA, *Dokl. Akad. Nauk SSSR*, 1957, **114**, 973—975. [Russian]

118. The elastic properties of chemically modified wools and their implications for theories of wool structure. H. LINDLEY, *Text. Res. J.*,

1957, **27**, 690—695. Biochemistry Unit, Wool Textile Research Lab., CSIRO, Melbourne, Victoria, Australia. Dependence of elastic properties on number and type of sulphur linkages discussed in terms of structure.

119. Viscosity of natural rubber solutions at very low rates of shear. M. A. GOLUB, *Rubb. Chem. Technol.*, 1957, **30**, 827—833 ; *Canad. J. Chem.*, 1957, **35**, 381—387. B.F. Goodrich Research Center, Brecksville, Ohio, U.S.A. Compares measurements of viscosity on natural rubber in benzene at shear rates down to less than 1 sec^{-1} with Bueche's theory.

120. Shear dependence of viscosity of natural rubber solutions. M. A. GOLUB, *Rubb. Chem. Technol.*, 1957, **30**, 823—826 ; *J. Phys. Chem.*, 1957, **61**, 374—375. B.F. Goodrich Research Center, Brecksville, Ohio, U.S.A. Presents results comparing shear dependence of viscosity for natural and synthetic polyisoprenes.

121. Viscosities of concentrated polymer solutions—IV. Cellulose tributyrate. R. F. LANDEL, J. W. BERGE, and J. D. FERRY, *J. Colloid Sci.*, 1957, **12**, 400—411. Department of Chemistry, University of Wisconsin, Madison, Wisconsin, U.S.A. Reports measurements of viscosities of different fractions over wide range of concentration at temperatures between $-5°$ and $50°$ C.

122. Anomalous viscosity behaviour of polymer solutions at very low concentrations. T. KAWAI, K. SAITO, and W. R. KRIGBAUM, *J. Polym. Sci.*, 1957, **26**, 213—226. Laboratory of Textile Chemistry, Tokyo Institute of Technology, Tokyo, Japan. A discussion of the apparent anomalies of the viscosity concentration curves in terms of a molecular theory. There is an appendix by the third author.

123. Intrinsic viscosity–molecular weight relationship for polychlorotrifluorethylene. E. K. WALSH and H. S. KAUFMAN, *J. Polym. Sci.*, 1957, **26**, 1—7. Jersey City Chemical Division, Minnesota Mining and Manufacturing Co., Jersey City 3, N.J., U.S.A. A high temperature osmotic pressure technique has been used to obtain molecular weight data in fractions of polychlorotrifluorethylene. Intrinsic viscosity data were obtained on samples at $130°$ C using a dilution viscometer. The results suggest a relatively rigid molecule. This is consistent with X-ray results.

124. Dynamic mechanical properties of poly-*n*-hexyl methacrylate. W. C. CHILD, JR. and J. D. FERRY, *J. Colloid Sci.*, 1957, **12**, 389—399. Department of Chemistry, University of Wisconsin, Madison, Wisconsin, U.S.A. Frequency range 15—2400 c.p.s. temp. range $5°$ to $125°$ C. Discussion in terms of reduced variables and chemical structure.

125. Propagation of stress waves in rubber rods. W. S. CRAMER, *J. Polym. Sci.*, 1957, **26**, 57—65. U.S. Naval Ordnance Laboratory, White Oak, Silver Spring, Maryland, U.S.A. Experimental investigation of propagation of longitudinal, torsional and flexural waves in rubber rods.

126. Hydrostatic pressure effect on polymer melt viscosity. BRYCE MAXWELL and ALEX JUNG, *Mod. Plast.*, Nov. 1957, 174—182, 276. Plastics Lab., Princeton Univ., N.J., U.S.A. The apparent viscosities of polyethylene and polystyrene at constant shearing stress were measured under hydrostatic pressure. At 24,000 p.s.i. the viscosity of polyethylene

had increased 14-fold and at 18,000 p.s.i. the viscosity of polystyrene had increased 135-fold. The apparatus is described and the results discussed in terms of polymer structure and effect on moulding operations.

127. Dynamic mechanical behaviour of some nylons. A. E. WOODWARD, J. A. SAUER, C. W. DEELEY, and D. E. KLINE, *J. Colloid Sci.*, 1957, **12**, 363—377. College of Chemistry and Physics, The Pennsylvania State University, University Park, Pennsylvania, U.S.A. Reports measured properties of nylons 6-6, 6-10 and a copolymer, at audio frequencies between ca. 80° K and their melting points. Discusses results in terms of a molecular model.

128. Viscosity of dilute solutions of preparations of deoxyribonucleic acid at low and medium rates of shear. H. EISENBERG, *J. Polym. Sci.*, 1957, **25**, 257—271. The Weizmann Institute of Science, Rehovot, Israel. Reports measurements of viscosities of DNA, as a function of rate of shear and conc. of polymer and of NaCl, made with a rotation viscometer.

129. Relaxation of stress in starch jelly candy. C. STERLING, *Cereal Chem.*, 1957, **34**, 238—246. Department of Food Technology, University of California, Davis, California, U.S.A. The rate of relaxation of stress in a starch confectionery jelly has been ascertained with a continuously recording instrument. One-day-old gel samples have been compressed to various degrees of strain for varying periods of time. Relaxation of the stress does not follow a Maxwellian curve (i.e. a curve for a simple Maxwell model). Limiting values of stress indicate a residual elastic response for which a modulus can be calculated. The time of relaxation and the ultimate stress attained vary with the amount of strain imposed. Elastic properties of the gel determine the value of the ultimate stress and of the stress at any particular time during the period of strain. The mechanical behaviour of the starch gel does not follow the superposition principle. Molecular changes are interpreted in the light of experimental results.

Section E

PASTES AND SUSPENSIONS

130. Stress–strain relations in a suspension of dumbbells. STEPHEN PRAGER, *Trans. Soc. Rheol.*, 1957, **1**, 53. Department of Chemistry, University of Minnesota, Minneapolis, Minn., U.S.A. Stress–strain relations are obtained for a dilute suspension of dumbbells, for both uniform and non-uniform velocity gradients. It is shown that such a fluid will not produce a Weissenberg effect in uniform, rectilinear shear flow, but that a small effect of this kind can be obtained if the shear rate is allowed to vary from point to point, as in parabolic flow between two fixed and parallel plates. The normal stress in the latter case is a result of the translational diffusion of the dumbbells.

131. The viscosity of suspensions of spheres—III. Sediment volume as a determining parameter. JAMES V. ROBINSON, *Trans. Soc. Rheol.*, 1957, **1**, 15.

The Mead Corporation, Chillicothe, Ohio. The upper limit of volume concentration for a suspension is the reciprocal of the relative sediment volume. The dependence of viscosity upon the volume concentration of a suspension is expressed by an equation of the form :

$$f(\text{viscosity}) = kV/(1 - S'V)$$

in which the parameter, S', is identified as the relative sediment volume. For suspensions of glass spheres, the parameter S', calculated from measured viscosities, is most nearly equal to directly measured relative sediment volume when :

$$(\text{viscosity}) = (\eta^{\frac{1}{3}} - 1)$$

132. Non-Newtonian fluid flow. A. B. METZNER, *Ind. Eng. Chem.*, 1957, **49**, 1429—1432. University of Delaware, Newark, Del., U.S.A. Applicability of the generalized Reynolds number to Bingham plastic and power-law non-Newtonians is shown in detail.

133. Characterisation of agitation effects in shaken flasks. R. P. RHODES and E. L. GADEN, *Ind. Eng. Chem.*, 1957, **49**, 1233—1236. Dept. of Chemical Engineering, Columbia University, New York 27, N.Y., U.S.A. The efficiency of rotary and reciprocating shakers in mixing liquid–solid systems has been studied. Creased flasks give improved performance.

134. Relationship of the viscosity to the settling rate of slurries. R. L. WHITMORE, *J. Inst. Fuel*, 1957, **30**, 238. From settling-tests on slurries of sized fractions of a rough methyl-methacrylate polymer powder sedimenting in aqueous solutions, the hydrodynamic volume of each fraction is calculated and shown to exceed the dry volume. It is found to be almost proportional to the surface area of the material, and is attributed to fluid held in the surface cavities of its constituent particles. The results are applied to viscosity measurements on similar powders and it is shown that under shear the liquid layer on the particles gives them properties similar to those of soft spheres. For a slurry to possess a low viscosity and high settling-rate the surfaces of the particles must be smooth. This is of more importance than their angularity or elongation. B.C.R.A.

135. Yield stress as a factor in the performance of greases. D. EVANS, J. F. HUTTON, and J. B. MATTHEWS, *Lubric. Engng*, 1957, **13**, 341—346. "Shell" Research Ltd., Chester, England. The apparatus and method are described. The correlation of results with aspects of bearing performance and grease dispensing show the importance of the yield stress/temperature curve.

136. A theory of thixotropy and its application to grease. S. J. HAHN, T. REE, and H. EYRING, *N.L.G.I. Spokesman*, June 1957, **21**, 12—20. University of Utah, U.S.A. The authors assume two kinds of flow units, one Newtonian and the other non-Newtonian. On the application of stress the non-Newtonian units (which are due to entanglements) transform into Newtonian units. If the concentration of flow units at a given stress depends on time then when this idea of transformation is introduced into the Lee–Eyring theory one obtains flow curves which exhibit thixotropy. Experimental details are given which show good agreement with the theory.

137. A theory on the working of butter applied to working machines of different types. H. MULDER and F. C. A. DEN BRAVER, *Proc. 14th Internat. Dairy Congr.*, **2**, 1957. Dairying Lab., Agric. Univ., Wageningen, Holland. The working of butter is considered as the flowing of an emulsion of high viscosity. The number (n) of collisions per sec of moisture droplets is given by Smoluchowski's equation :

$$n = \frac{4aR^3}{3} \cdot \frac{dv}{dx}$$

where n is number of droplets/ml, R = sphere of attraction and dv/dx is velocity gradient. Not all collisions will cause coalescence, especially at low temps. The theory is discussed semi-quantitatively in relation to the conditions in different types of churn.

138. Relationship of the strength of high solids pectin gels to the concentration and jelly-forming capacity of the pectin present. P. WADE, *Nature, Lond.*, 1957, **180**, 1067—1068. The Laboratories, Chivers & Sons, Ltd., Histon, Cambridge, England. Gel strength, which can be related to the shear modulus, is compared with the concentration of various pectins. A general equation is suggested to fit the results.

139. The humus content of clays and the effect of treatment with hydrogen peroxide on some colloidal properties. Y. SHIRAKI, *J. Ceram. Ass. Japan*, 1957, **65**, 55. There is no relationship between the humus content and the colour of the clay ; no connection was found between humus content and *p*H-value or swelling of clays ; H_2O_2 decomposes the humus-clay complex to a greater or lesser degree and eliminates soluble salts so that treated clay has a high degree of dispersion and increased viscosity ; clay treated with H_2O_2 has a low sedimentation rate and a high sedimentation vol. ; humus is decomposed at about 250°—550° ; decomposition of Fe-compounds on introduction of SO_2 is accelerated by addition of H_2O_2.
B.C.R.A.

140. Effect of temperature on the structure formation in clay suspensions. T. M. POLONSKII, *Vestn. Akad. Nauk Byelruss. S.S.R., Ser. Fiz.-Tekh. Nauk*, 1956, No. 2, 147, from *Chem. Abstr.*, 1957, **51**, 3953. A sample of bentonite (I) containing (%) : SiO_2, 52.4 ; Al_2O_3, 12.5 ; Fe_2O_3, 4.3 ; CaO, 2.69 ; MgO, 1.0 ; TiO_2, 0.50 ; Na_2O, 0.12 ; H_2O, 27.2 ; was suspended in water (10, 16 and 18% I) and in 0.06*N* NaOH (8% I), the suspensions heated at 0°, 20°, 30°, 40°, and 50° (aq. suspensions) and at 60° (alkaline suspension) followed by determination of their tenacities by means of the Veller and Rebinder elastomer (C.A. 40, 5963[8]). The tenacity of the structure in the I suspensions increases with the time of the structure formation. The firmness of the structure in the thixotropic I suspensions increases with the temperature of the structure formation until 50°—60°, followed by a decrease with the higher temperature. The Veller Rebinder elastomer is useful for studying the temperature effect on the physical properties of dispersed systems. [Russian] B.C.R.A.

141. Storage stability of polyvinyl acetate emulsion paints. H. W. CHATFIELD, *Paint Manuf.*, 1957, **27**, No. 9, 340—343 ; No. 10, 386—389. Hydroxy ethyl cellulose (as stabiliser) shows more tendency to develop thixotropy than normal methyl cellulose ether in these systems.

142. Paint and lacquer additives. W. F. DAGGETT, *Paint Manuf.*, 1957, **27**, No. 9, 336—339, 357. Modifiers of rheological properties and means of increasing thixotropy are discussed. The viscosity of cellulose lacquers can be drastically reduced by 1—2% of certain solvents, e.g. acetone. Thixotropic alkyds can be added to linseed oil paints to reduce sagging and improve storage stability. The presence of alcohol groups destroys the gel structure set up by the addition. Aluminium stearate and other metal soaps are widely used to increase the thixotropy of surface coatings.

143. PATRA's work on printing inks. ANON., *Paint Manuf.*, 1957, **27**, No. 8, 298. Research on printing inks carried out in the last year at the laboratories of the Printing and Allied Trades Research Association at Leatherhead, Surrey, has been concerned mainly with oxidation drying of inks, the penetration of ink into paper and the fluffing of paper. Work will be continued in future on the fundamental flow properties of inks and the distribution of inks by roller systems.

OL.
1
958

Section F

LIQUIDS

144. On the relation between the viscosity and molecular structure of liquids. A. Z. GOLIK and D. N. KARLIKOV, *Dokl. Akad. Nauk SSSR*, 1957, **114**, 361—364. [Russian]

145. Distortion of fluid drops in the Stokesian region. F. H. GARNER, K. B. MATHUR, and V. G. JENSON, *Nature, Lond.*, 1957, **180**, 331—332. Dept. of Chemical Engineering, Univ. of Birmingham, England. A brief note on the distortion of $CHCl_3$ and CCl_4 drops when falling in glycerol.

146. The causes responsible for the surface swelling of a liquid under the action of ultrasound. L. D. ROSENBERG and L. O. MAKAROV, *Dokl. Akad. Nauk SSSR*, 1957, **114**, 275—276. [Russian]

147. The need for a viscosity classification of industrial lubricants. G. D. JORDAN, *Sci. Lubric.*, October 1957, **9**, 22—25. Outlines work done by the A.S.T.M. and other authorities in classifying oils into groups, each group being defined by upper and lower viscosity limits. Four proposed classifications are compared.

148. An experiment on the measurement of the viscosity of an expanded liquid. A. P. TOROPOV and A. I. KITOVA, *Sov. Phys. J.E.T.P.*, 1957, **5**, 315—317. Central Asia State University. The difference in viscosities of benzine under isotropic tensile stress and under atmospheric pressure was determined by a falling-ball method. The difference lay just outside the stated experimental error in 5 out of the 8 reported cases.

149. New B.S. determination of the viscosity of liquids in C.G.S. units. ANON., *Scientific Lubrication*, October 1957, **9**, 20. A short note indicating the scope of the new standard B.S.188 : 1957.

150. The viscosity of liquid indium and liquid tin. M. F. CULPIN, *Proc. Phys. Soc. Lond. B*, 1957, **70**, 1069—1078. Royal Institution, London, England. Measurements of the viscosity of liquid indium and

liquid tin have been made, using the oscillating sphere viscometer. A preliminary set of measurements on bromine was made. The viscosity was determined over a range of temperature in each case, and the results compared with Andrade's theory of the viscosity of liquids. A comparison is also made between the many sets of values of the viscosity of tin already published. Author

151. The viscosity of liquid magnesium and liquid calcium. M. F. CULPIN, *Proc. Phys. Soc. Lond. B*, 1957, **70**, 1079—1088. Royal Institute, London, England. In a previous paper measurements of the viscosity of indium and tin are described. The experimental technique described there, viz., the method of the oscillating hollow sphere, has been modified to enable measurements of the viscosity of liquid magnesium and calcium to be made. Author

VOL.
1
1958

152. The differential coefficient of viscosity with temperature as a measure of the viscosity–temperature gradient. H. STOLTE, *Erdöl u Kohle*, 1957, **10**, 451. Oelwerke Julius Schindler G.m.b.H., Hamburg, Germany. Normally the gradient is calculated from viscosity measurements at two closely-spaced temperatures, giving the difference ratio $\Delta\nu/\Delta T$. Smaller errors will be introduced if the differential coefficient $d\nu/dT$ is calculated using equations derived from the Walther or the Umstätter viscosity–temperature relations and a single viscosity measurement. [German]

153. The viscosity/temperature relationships of lubricating oils. E. G. ELLIS, *Petroleum, Lond.*, 1957, **20**, 294—298. This article reviews many of the empirical methods which have been proposed to characterise the viscosity/temperature relationships of lubricating oils. The various disadvantages of each method are given. The author points out that as the viscosity/temperature relationship is a function of more than one variable it can never be described by a single figure.

154. Effect of temperature and solute volume on liquid diffusion coefficients. K. K. INNES and L. F. ALBRIGHT, *Ind. Eng. Chem.*, 1957, **49**, 1793—1794. Vanderbilt University, Nashville, Tenn., U.S.A. Experimental data are presented in support of the equations $D=AT^n e^{-B/T}$ and $DV^m=K$.

155. Mixing during successive pumping of petroleum products along pipe lines. V. A. YUFIN, *Neftyanoe Khoz.*, 1957, p. 54. From D.S.I.R. Translated Contents List No. 104, Nov. 1957. [Russian]

156. Dispersion of soluble matter in flow through granular media. M. J. BERAN, *J. Chem. Phys.*, 1957, **27**, No. 1, 270—274. Harvard University, Cambridge, Mass.

157. Flow of steam–water mixtures at high pressures. R. W. HAYWOOD, *Nature, Lond.*, 1957, **180**, 357—358. Engineering Laboratory, Univ. of Cambridge, England. Outline of experiments to obtain data on circulation rates, in which γ-rays are used to measure flow-rates.

158. Viscosity of molten slags of the manganous oxide–silica–alumina system. SH. M. MIKIASHVILI, A. M. SAMARIN, and L. M. YSYLEV, *Bull. Acad. Sci. U.R.S.S.*, 1957, No. 1, 115. [Russian] B.C.R.A.

159. Synthetic ester lubricants. R. S. BARNES and M. Z. FAINMAN, *Lubric. Engng.*, 1957, **13**, 454—458. Standard Oil Co., Whiting, Indiana. U.S.A. Friction and viscosity data are given for 48 esters made from polyhydric alcohols and monobasic acids. These esters have greater thermal stability than the more common dibasic ester lubricants. A critical discussion follows the paper.

160. Viscosity studies on industrial nitrocellulose. O. P. GUPTA and T. E. VENKATACHARI, *J. Sci. Industr. Res.*, 1957, **16A**, 472—475 Cordite Factory, Aruvankadu, India. Viscosities, measured at temperatures between 10° and 40° C. are given for nitrocellulose at several concentrations in three different solvent mixtures.

161. Effects of gamma radiation on commercial lubricants. J. G. CARROLL and S. R. CALISH, JR., *Lubric. Engng.*, 1957, **13**, 388—392. Twenty-eight oils and greases were exposed to gamma rays at about 80° F. Exposures ranged from 1×10^8 to 9×10^8 roentgens. The effects of radiation on viscosity and other properties are given.

162. The rheological properties of surface layers at the oil-water interface and their role in the stability of oil emulsions. M. M. KUSAKOV *et al.*, *Dokl. Akad. Nauk SSSR*, 1957, **116**, No. 4, 637 (via *D.S.I.R. list* No. 108, March 1958). [Russian]

Section G

GENERAL

163. Proposed nomenclature for linear viscoelastic behaviour. HERBERT LEADERMAN, *Trans. Soc. Rheol.*, 1957, **1**, 213. National Bureau of Standards, Washington 25, D.C., U.S.A.

164. Definitions of terms relating to the lubricating grease industry. W. J. EWBANK, *N.L.G.I. Spokesman*, Sept. 1957, **21**, 9—11. Cato Oil and Grease Company. Eighteen definitions of terms relating to the lubricating grease industry are given. These definitions were finally decided upon by the committee on definitions first set up by the N.L.G.I. in 1952. These definitions relate to the general field of grease consistency.

165. Reference levels for viscosity specifications. SOCIETY OF GLASS TECHNOLOGY, *J. Soc. Glass Tech.*, 1956, **11**, 58P. Report by the Physical Properties Committee. Defines two reference levels : " The 13.0 temperature " and " The 7.6 temperature ", these being the temperatures at which a glass has a viscosity of 10^{13} and $10^{7 \cdot 6}$ poises respectively. B.C.R.A.

166. The tackiness of liquid adhesives. J. J. BIKERMAN, *Trans. Soc. Rheol.*, 1957, **1**, 3. Department of Civil and Sanitary Engineering, Massachusetts Institute of Technology, Cambridge 39, Mass., U.S.A. Tackiness, i.e., the resistance of adhesive joints to separation as long as the adhesive is liquid, is determined by the rheology of the adhesive and is not affected by molecular adhesion. If the adhesive is a Newtonian liquid, tackiness is governed by Stefan's equation $4ft\delta^2 = 3\eta r^2$; f is the applied stress, t time of separation, δ initial thickness of the liquid film, η its

viscosity, and r radius of the adherend plates. This equation was confirmed for two hydrocarbon oils between surfaces of copper, nickel, or stainless steel ; the oil film thickness calculated from the experimental values of ft was in accord with the thickness determined from the electrostatic capacity. The degree of flatness and smoothness of the metal surfaces greatly affected the value of ft ; the deviations from the theory recorded in earlier papers may have been due to disregard of waviness and rugosity. In the conditions of this work, the product ft was, at a first approximation, inversely proportional to the average height of hills on the metal surface.

167. Deposition of suspended particles from turbulent gas streams. S. K. FRIEDLANDER and H. F. JOHNSTONE, *Ind. Eng. Chem.*, 1957, **49**, 1151—1156. University of Illinois, Urbana, Ill., U.S.A. The rate of deposition of iron, aluminium and lycopodium powders from turbulent streams of air appears to be due to the inertial effect of the eddies, rather than to Brownian diffusion, gravitation or electrostatic forces. The application of an adhesive to the wall of the base did not change the rate of deposition. Some analytical treatment is given.

VOL.
1
195

168. Evaluation of mixing efficiency of processing equipment. A. BEERBOWER, E. O. FORSTER, J. J. KOLFENBACH, and H. G. VESTERDAL, *Ind. Eng. Chem.*, 1957, **49**, 1075—1078. Products Research Divisions, Esso Research and Engineering Co., Linden, N.J., U.S.A. Iodine 132 is used to evaluate the mixing efficiency of process equipment in a short time. The products are not permanently contaminated. I^{132} (half life 2·3 hr) is obtained from tellurium dioxide (half life 7·7 hr) by chemical treatment. It is cheap and readily available, since Te^{132} is a by-product of uranium fission.

169. On the change of electrical resistivity by elementary slip. E. D. SHCHUKIN, V. N. ROZHANSKI, and J. V. GORIUNOV, *Dokl. Akad. Nauk SSSR*, 1957, **115**, 1101—1103.

170. How to predict gravity flow rates. F. A. ZENZ, *Petrol. Refin.*, 1957, **36**, 162—170. Roslyn Harbour, Long Island, New York, U.S.A. Reviews the work done on the prediction of the flow rates of powders flowing through restrictions. Restrictions such as vertical pipes, orifices and conical-bottom hoppers are dealt with. Charts are given for calculating the flow rates in these cases. Corrections which are necessary due to wall effects are also given.

171. Effect of pH on bromated and unbromated doughs. I. HLYNKA and W. G. CHANIN, *Cereal Chem.*, 1957, **34**, 371—378. Board of Grain Commissioners for Canada, Winnipeg 2, Manitoba, Canada. To study the effect of pH on the reaction of bromate in dough, experiments were done on bromated (20 p.p.m.) and on untreated control doughs adjusted to pH 7.0, 5.8, and 4.7 with sodium hydroxide, lactic or acetic acid. Structural relaxation data on bromate-treated flour–water–salt doughs showed that the relaxation constant and the asymptotic load increased as acidity increased from pH 7.0 to pH 4.7. There was also a smaller effect of acid alone on dough properties. Data from test baking experiments in which the initial pH of dough was adjusted showed that the

optimum bromate requirement decreased with increasing acidity in the same pH range. The effect of lactic and acetic acids in dough and in bread was similar.

172. The influence of the water-soluble constituents of wheat flour on its mixing and baking characteristics. P. J. MATTERN and R. M. SANDSTEDT, *Cereal Chem.*, 1957, **34**, 252—267. Nebraska Agricultural Experiment Station, Nebraska, U.S.A. Farinograms, mixograms and baking test data are presented to show that the principal factor responsible for determining the mixing requirements of wheat flour is water soluble and consists largely of gliadin.

OL.
1
958

LIST OF JOURNALS COVERED FOR RHEOLOGY ABSTRACTS

Analyt. Chem.
Ann. N.Y. Acad. Sci.
Appl. Sci. Res., Gravenhage.
Arch. Mech. Storowany.
A.S.T.M. Bull.
Aust. J. Appl. Sci.
Aust. J. Phys.

Bitumen, Teere, Asphalte u. Peche
Brit. Chem. Engng.
Brit. J. Appl. Phys.
Brit. Plast.
Brot. u. Gebäck.
Bull. Acad. Sci. U.R.S.S.
Bull. Amer. Ceram. Soc.

Canad. J. Chem.
Canad. J. Phys.
Cereal Chem.
Chem. Rev.
Chim. et Industr.
Clays and Clay Min.
Clay Min. Bull.
Coll. Trav. Chim. Tchécosl.
C.R. Acad. Sci.

Dairy Ind.
Diss. Abs.
Dokl. Akad. Nauk SSSR
DSIR Contents List

Engineer, Lond.
Engineering, Lond.
Erdöl u. Kohle

Faserforschung
Fluid Handling
Food Tech.

Glass Ind.
Glastech. Ber.
Glycerine News

Helv. Chim. Acta.
Helv. Phys. Acta.

Ind. Eng. Chem.
Indust. Chem.
Instrum. Pract.

J. Amer. Ceram. Soc.
J. Amer. Chem. Soc.
J. Amer. Leath. Chem. Ass.
J. Amer. Oil Chem. Soc.
J. Appl. Mech.
J. Appl. Phys.
J. Ceram. Ass. Japan
J. Chem. Educ.
J. Chem. Phys.
J. Chem. Soc.
J. Chim. Phys.
J. Colloid Sci.
J. Dairy Res.
J. Dairy Sci.
J. Fluid Mech.
J. Franklin Inst.
J. Imp. Coll. Chem. Engng. Soc.
J. Inst. Fuel
J. Inst. Met.
J. Inst. Petrol
J. Mech. Phys. Solids
J. Oil Col. Chem. Ass.
J. Phys. Chem.
J. Polym. Sci.
J. Rat. Mech. Anal.
J. Res. Nat. Bur. Stand.
J. Sci. Fd. Agric.
J. Sci. Industr. Res.
J. Sci. Instrum.
J. Soc. Dy. Col.
J. Soc. Glass Tech.
J. Soc. Leath. Tr. Chem.
J. Soil Sci.
J. Text. Inst.

Kolloidni Zh.
Kolloidzschr.
Kunststoffe

Lab. Practice
Lubric. Engng.

Mod. Plast.

Nature, Lond.
Neftyanoe Khoz.
NLGI Spokesman
Nuovo Cim.

Oil Ind., Moscow

Paint Manuf.
Paint Tech.
Petrol Engr.
Petrol Process.
Petrol Refin.
Petroleum, Lond.
Phil. Mag.
Phil. Trans.
Phys. Rev.
Plastics, Lond.
Plastics Tech.
Proc. Camb. Phil. Soc.
Proc. Phys. Soc. Lond.
Proc. Roy. Soc.
Proc. Soil Sci. Soc. Amer.
Process Control

Quart. Appl. Math.

Research, Lond.
Rev. de l'Inst. franç. du pétrole
Rev. Inst. Franc. Petrole.
Rev. Mod. Phys.

VOL.
1
1958

LIST OF JOURNALS COVERED FOR RHEOLOGY ABSTRACTS

Rev. Sci. Instrum.
Rubb. Chem. Technol.

Sci. Lubric.
Silicates Industr.
Soil Sci.
Sov. Phys. JETP
S.P.E.J.
Spokesman
Svensk Pappers Tidning

Tappi

Text. Res. J.
Trans. Brit. Ceram. Soc.
Trans. Faraday Soc.
Trans. Plast. Inst., Lond.
Trans. Soc. Rheol.

Verres et Réfr.

Wire Ind.
Wire Prodn.
Wire and Wire Prodn.

OL.
1
958

VOL.
1
1958

PRINTED IN GREAT BRITAIN BY METCALFE & COOPER LTD., 10-24, SCRUTTON STREET, LONDON, E.C.2

Section A

THEORETICAL

173. Work-hardening, elastic after-effect and residual stresses in the light of the dynamical theory of plasticity. J. MADEJSKI, *Rozpr. Inzyn.*, 1957, **5**, (4), 455—479. The rheological properties of a model represented by a honeycomb structure of hard (wax) walls containing a soft (honey) solution, both components capable of interdiffusion, are investigated. The results are used to discuss work-hardening and crystallite fragmentation in metals, the latter being regarded as examples of a material having the properties of the model. [Polish] P.F.

174. Application of the Laplace transform to the computation of rheological states in pre-stressed structures. CZ. EIMER, *Rozpr. Inzyn.*, 1958, **6**, (1), 181—199. [Polish] P.F.

175. The influence of viscous damping on the form of the trajectories of free vibrations. S. ZIEMBA, *Arch. Mechaniki Stosowanej*, 1957, **9** (4), 487—504. [English] P.F.

176. Free vibration of a system with one degree of freedom with non-linear characteristics, taking into consideration linear viscous damping. R. GUTOWSKI, *Arch. Mechaniki Stosowanej*, 1957, **9**, (6), 647—668. [English] P.F.

177. Theory of similarity of thermo-elasto-plastic phenomena. J. MADEJSKI, *Rozpr. Inzyn.*, 1957, **5**, (4), 497—513. Criteria of similarity of thermo-elasto-plastic states in similarly shaped bodies are derived, and certain dimensionless parameters discussed. Practical applications are considered ; an example concerning the creep-strength of superheater tubes is worked out on the basis of published data given by Kats in *Teploenergetika*, Vol. 11, 1955, p. 37. [Polish] P.F.

178. Influence of initial stresses on the vibration of bars of constant cross-section. W. BOGUSZ, *Rozpr. Inzyn.*, 1958, **6**, (1), 103—118. A method for determining the internal stresses by means of vibration measurements is discussed. [Polish] P.F.

179. Linear damping of a single impulse by a non-linear shock-absorbing system. J. SKOWRONSKI, *Rozpr. Inzyn.*, 1958, **6**, (1), 119—142. [Polish] P.F.

180. Reduced pressure as a strength parameter. J. ZAWADSKI, *Rozpr. Inzyn.*, 1957, **5**, (3), 357—399. Compression of a crystalline body induces changes in the vibrational entropy of the lattice, and leads to changes in the mechanical properties, such as resistance to plastic deformation. Effects of this type are allowed for in a modification of the Hencky-Mises yield criterion. Applications are discussed. [Polish] P.F.

181. The theory of plasticity with the Bauschinger effect taken into account. YU. I. KADASHEVICH *et al.*, *Dokl. Akad. Nauk SSSR*, 1957, **117**, No. 4, 586. (From *D.S.I.R. List* No. 109, April 1958, p.23.) [Russian]

182. On the problem of axial bending of a rod of variable rigidity. Ya. D. Mamedov, *Dokl. Akad. Nauk SSSR*, 1958, **118**, No. 1, 33. (From *D.S.I.R. List* No. 110, May 1958.) [Russian]

183. Concerning the theory of fatigue failure in textile materials. W. J. Lyons, *Text. Res. J.*, 1958, **28**, 127. Textile Research Institute, Princeton, N.J., U.S.A. A minor modification of the reaction rate theory of flow is proposed with the aim of accounting, in terms of molecular processes, for the observed dependence of dynamic properties, particularly fatigue, on the frequency of stressing. D.W.S.

184. Theory of peeling through a Hookean solid. J. J. Bikerman, *J. Appl. Phys.*, 1957, **28**, 1484—1485. Massachusetts Institute Technology, Cambridge, Massachusetts, U.S.A. When the adhesive is a Hookean solid and the adhesive joint between a rigid plate and a flexible ribbon is peeled, the force required for peeling is $0{\cdot}3799\ W\sigma\ (E/E_1)^{\frac{1}{3}}\delta^{\frac{1}{3}}Y_0^{\frac{1}{3}}$, if W denotes the width of ribbon, σ the tensile strength of the adhesive, E and E_1 the moduli of elasticity of the ribbon and the adhesive, respectively, δ the thickness of the ribbon, and Y_0 the initial thickness of the adhesive film. If $\delta = Y_0$, the ratio of tensile force to stripping force needed for separation is of the order of l/Y_0, l being the length of the ribbon. G.H.T.

185. On simplification of non-linear integral equations of creeping and relaxation in a complex strained state. M. I. Rozovskii, *Zh. tekh. fiz.*, 1957, **27**, No. 12, 2791. (From *D.S.I.R. List* No. 109, April 1958, p. 148.) [Russian]

186. Evaluation of retardation (creep) tests with the aid of the generalized Kelvin-Voigt model—I. Loading curves. F. Winkler, *Faserforschung*, 1958, **9**, 30—36. Deutsche Akademie der Wissenschaft zu Berlin, Institut für Faserstoff-Forschung in Teltow-Seehof. It is assumed that, in a simple elongation experiment under constant load, the elongation may be represented by a sum of three exponential functions of time. A method of determining the appropriate coefficients and exponents from experimental data is developed. This method differs from that of Kukin and Solowjew (see abstract 274) and, applied to their data for high-tenacity viscose, gives a seven times better fit than that given by their method. [German] A.S.L.

187. A note on stress pulses in visco-elastic rods. D. S. Berry, *Phil. Mag.*, 1958, **3**, 100—102. A brief mathematical treatment of relationship between transient stress a in semi-infinite visco-elastic rod and the alteration coefficient and phase velocity as functions of steady state frequency. Disagreement is found with Kolsky's result. Reasons for this are discussed. G.H.T.

188. Uniqueness of the solution of approximate boundary problems in the dynamics of an incompressible fluid of variable viscosity. S. A. Regirer, *Dokl. Akad. Nauk SSSR*, 1957, **117**, No. 3, 384. (From *D.S.I.R. List* No. 109, April 1958, p. 19.) [Russian]

189. On the stability of viscous flow in a curved channel. W. H. Reid, *Proc. Roy. Soc.* A., 1958, **244**, 186—198, Yorkes Observatory, University of Chicago, Ill., U.S.A. The author discusses the stability of a Newtonian viscous liquid flowing in a curved channel formed by two concentric

cylinders due to a pressure gradient acting around the cylinders when the spacing between them (d) is small compared with the radius of the inner cylinder (R_1). The two methods of solution show that instability first sets in when the dimensionless parameter $R\sqrt{(d/R_1)}$ attains the value 36, where R is the Reynolds number. J.R.J.

190. Representation of the temperature dependence of viscosity of oils by the method of true exponents. L. ANDRUSSOW, *Erdöl u. Kohle*, 1957, **10**, 856—862. 71 Rue Laugier, Paris 17. After a review of earlier equations of temperature dependence the method of exponents is explained. It is based on a hyperbolic function in which the temperature exponent is itself a function of temperature. Two exponents are defined : a " true " and a " mean " which are calculated respectively from measurements taken over small and quite large temperature intervals. Advantages are pointed out for the use of curves of exponent against temperature for the comparison of oils and the accurate calculation of viscosity. The mean exponent is of more practical value. A discussion by K. K. Rumpf and H. Stolte follows the paper. [German] J.F.H.

191. The paths of approach and recession of two spheres in a shearing viscous liquid. M. MOONEY, *J. Colloid Sci.*, 1957, **12**, 575. The General Laboratories of the United States Rubber Company, Passaic, N.J., U.S.A. It is shown theoretically that the paths of approach and recession of two rigid spheres in a shearing liquid are curvelinear and mirror images of one another. D.W.S.

192. The finite length partial fitted journal bearing with axial oil groove. M. J. JACOBSON, *Quart. Appl. Maths.*, 1958, **16**, 1—10. Rensselaer Polytechnic Institute, Troy, N.Y., U.S.A. An analytical expression is obtained for the pressure distribution in the lubricating film of a finite length partial fitted journal bearing when the lubricant is introduced under constant pressure through an axial bearing groove. The pressure distribution is found to differ appreciably from that calculated for the corresponding infinite length bearing, especially near to the ends where it falls to zero. R.R.

193. Slit nozzles : their calculation and design. H. R. JACOBI, *Kunststoffe*, 1957, **47**, No. 11, 647. An expansion of the mathematical calculations for slit nozzles previously published in *Mod. Plastics*, 1956, **33**, No. 8. [German] E.B.

194. Thermodynamic relations among stresses, deformations and moisture absorption. J. W. S. HEARLE, *Text. Res. J.*, 1957, **27**, 940. College of Technology, University of Manchester, England. A new form of the derivation of the relation between moisture absorption, swelling and applied stresses has been given and has been used to obtain the equations applicable to textile systems. They are strictly valid only under reversible conditions. Some applications of these equations have been suggested. They may also be of value in dealing with other problems, particularly in relation to the dimensional stability of material under changing moisture conditions, which is sometimes a serious defect in use. Author

195. The mechanism of filter pressing and slip casting. D. S. ADCOCK and I. C. MCDOWALL, *J. Amer. Ceram. Soc.*, 1957, **40**, 355—362. New Zealand Pottery Res. Ass., Lower Hutt, N.Z. The deposition of the clay layer is studied in view of the Kozeny equation. Both processes can be considered as simple dewatering processes. B.N.

Section B

INSTRUMENTS AND TECHNIQUES

196. A simple instrument for the periodic application of controlled bi-axial strains. P. U. A. GROSSMAN, *J. Sci. Instrum.*, 1958, **35**, 131—134. Dept. of Colloid Science, University of Cambridge, England. This instrument produces harmonically varying strains in a thin layer of test material and controls in 2 dimensions the frequencies, amplitudes and phases. Weissenberg's method of a flexible boundary is employed to obtain homogeneous strain and a uniform break-up pattern when fatigue failure is approached. The specimen adheres to the surface of a rubber sheet which is extended in 2 directions by sets of parallel strings fastened to sliding carriages. The carriages follow circular cams, one directly and one through a lever. The cams are interconnected by a chain and rotated by hand or motor. Phase difference is set by positioning the chain wheels, ratio of amplitudes by adjusting the fulcrum of the lever, and ratio of frequencies by the size of the chain wheels. To illustrate the applications, the fatigue of powders under various testing conditions is described and the emergent break-up patterns are discussed.

197. The recording of pressure distributions in porous media during fluid flow experiments. T. O'DONNELL, D. H. EDWARDS, N. COLLIS-GEORGE and E. G. YOUNGS. *J. Sci. Instrum.*, 1958, **35**, 63—64. Agricultural Research Council, Unit of Soil Physics, Huntingdon Road, Cambridge. A null-point method is described of recording in a short time interval pressure distributions in a porous medium during fluid flow experiments. Small cells are buried at numerous points in a porous material, and the pressure distribution is recorded by measuring the internal air pressure required to balance the external hydraulic pressure on the cells. W.G.C.

198. A modification for use with wire resistance strain gauge circuits. J. HALLING, *J. Sci. Instrum.*, 1958, **35**, 72. Dept. of Mechanical Engineering, The University, Liverpool. A simple, robust apparatus for measuring the strain on a light beam, subjected to uniform bending, is described. W.G.C.

199. Automatic control of the viscosity of slurry. YA. E. GEL'FAND and L. A. GIRSHOV, *Tsement*, 1957, No. 6, 15. (From *D.S.I.R. List* No. 109, April 1958, p. 118.) [Russian]

200. Measurement of external pressure properties of lubricants. Anon. *A.S.T.M. Bull.*, 1958, **228**, 28. A proposed test method for determining the load carrying capacity of lubricating oils and lubricating greases by means of the Timber Extreme Pressure Tester, based upon the experience

accumulated in the various co-operative programmes initiated by the Special Committee on Measurement of Extreme Pressure properties of A.S.T.M. Committee D-2. E.B.A.

201. Rotation viscometer directly measuring the ratio of the shearing stress to the rate of shear. H. EISENBERG, *Rev. Sci. Instrum*, 1951, **28**, 11, 927—929. In the rotating cylinder viscometer described the time interval between the passage of the extremities of the rotating spring past a fixed point is a measure of the ratio S/G. An optical method of measuring this time is described. H.J.R.

202. Conditions of plastic deformation in welding PVC sheeting. H. HALDENWANGER and W. BERGER, *Kunststoffe*, 1958, **48**, 13—16. Hanoverschen Wachstuck und Kunstlewerke J. H. BENECKE, Vinnhorst/Hanover. An instrument has been developed by means of which the dependence of plastic deformation of PVC on temperature, time and pressure can be determined. The test relates to the welding of PVC sheeting (reduced Authors Abstract). [German]. E.B.

203. Brittleness temperature testing of elastomers and plastics. A. C. WEBBER, *A.S.T.M. Bull.*, 1958, **227**, 40—44. Research Division, du Pont, Wilmington, Del., U.S.A. A report of work by a task group of an A.S.T.M. sub-committee on Low Temperature testing of elastomers and plastics. Two methods of measuring low temperature brittleness were found to be in general use, and only one of these (A.S.T.M. method D.746—55T) was useful over the range of materials tested. E.B.A.

204. A study of low temperature brittleness testing of polyethylene. E. A. W. HOFF and S. TURNER, *A.S.T.M. Bull.*, 1957, No. 225, 58. Low temperature brittleness tests do not give unique values for polyethylene but depend markedly on specimen preparation. If brittleness test results are to be meaningful and reproducible, a more stringent specification covering specimen preparation and conditioning is needed. (Abstract from *Plastics Technology*, 1957, p. 1023.) E.B.

205. Measurement of P.V.C. brittle point. H. O. WILLIAMS, *Brit. Plast.*, March 1958, 107—111. I.C.I. Leathercloth Division. A method is described in which a folded strip cooled on an anvil in a bath of methylated spirits is struck by a flat ended spring-loaded plunger. Brittleness temperatures obtained thus have a standard deviation of less than 0·5°C and are insensitive to specimen thickness. E.B.A.

206. Long-term rupture and impact stresses in reinforced plastics. S. GOLDFEIN, *A.S.T.M. Bull.*, 1957, **224**, 36. A new method is described for evaluating strength data as a function of time and temperature. This involves determination of rupture properties at various temperatures by standard test methods and a mathematical and graphical relationship to determine rupture properties for extremely short and long periods of time. (Abstract from *Plastics Technology*, 1957, p. 1023.) E.B.

207. Impulse testing of reinforced-concrete beams. F. T. MAVIS and M. J. GREAVES, *A.S.T.M. Bull.*, 1957, **226**, 43—47. Dept. of Civil Eng., Carnegie Inst. Technology, Pittsburg, Pa., U.S.A. A loaded spring device is used to apply loads of up to 9000 lb. simultaneously to a pair

of concrete beams in 3 point loading. Simultaneous records of the beam deflections and the reactions at the loading points were obtained using oscillographic recorders and a high speed camera. E.B.A.

208. A recording torsion testing machine for wire. H. C. BURNETT, *A.S.T.M. Bull.*, 1958, **227**, 68—69. Nat. Bur. Standards, Washington, D.C., U.S.A. Torsional moment vs. angle of twist curves are recorded by a frictionless device using an electric spark to mark heat sensitive paper. E.B.A.

209. Autographic stress-strain recorders. R. R. BOUCHE and D. R. TATE, *A.S.T.M. Bull.*, 1958, **228**, 33—42. National Bureau of Standards. Describes the operating principles of stress–strain recorders and their evolution. Information on a number of commercially available machines is given and results of a performance test on three representative of many in use today. 93 references. E.B.A.

VOL.
1
195

210. A lateral extensometer for the determination of Poisson's ratio of rock. E. R. LEEMAN and C. GROBBELAAR, *J. Sci. Instrum.*, 1957, **34**, 503—505. National Mechanical Engineering Research Institute, Pretoria, South Africa. The apparatus described reads or records, up to fracture, the lateral strain occurring in a cylindrical rock specimen (subjected to a linear axial compressive load—cf. Abstract 36, *ibid.*, 279—280—by means of a linear variable differential transformer. Accuracy is consistently better than 5%, since deformations of the order of 1μ inch can be measured. W.G.C.

211. Testing machine for short-time creep and stress-rupture testing at 2000—2500° C. M. C. SMITH, D. M. OLSON and H. L. BROWN. *Rev. Sci. Instrum.* **28**, 7, 543—547. The machine described may be used for testing metallic and non-metallic specimens in vacuum or in a gas atmosphere at static tensile loads up to 100,000 p.s.i. H.J.R.

212. Constant head rate testing machine with instantaneous speed change. M. J. MANJOINE, E. T. WESSEL and W. H. PRYLE, *A.S.T.M. Bull.*, 1957, **226**, 31—35. Westinghouse Res. Labs., Pittsburgh, Pa., U.S.A. Describes a constant strain rate tensile testing machine giving strain rates variable from 0·0001 in. per hour to 120 in. per hour. Loads are measured by an electrical force gauge and head speeds may be changed instantaneously in magnitude or direction. E.B.A.

213. A high-speed tension testing machine. S. STRELLA, A. SIGLER* M. CHMURA* and B. HOLMAN*. *A.S.T.M. Bull.*, 1958, **228**, 50—52. *Picatinny Arsenal. A tester is described which will fracture a specimen within 5—40 msec and record the stress–strain curve. Loading is by means of a compressed air cylinder and stress is measured by means of a steel weighbar and strain gauge. E.B.A.

214. High speed tensile tests of theroplastics. R. E. ELY, *Plastics Technology*, 1957, No. 11, 900—903, 910. Ordnance Missile Laboratories, Redstone Arsenal, Huntsville, Ala., U.S.A. A high speed tensile tester and Instron tensile tester were used to fracture cellulose acetate-butyrate and polymethyl methacrylate in times ranging from 1·5 msec to 15 min. Stress–strain and maximum stress–time graphs are given. E.B.

215. Mechanical test methods for the evaluation of compositions containing bitumen and tar. TH. TEMME (Cologne), *Bitumen, Teere, Asphalte u. Peche*, 1958, **9**, 73—77. Describes the more important test methods and recent modifications made thereto. The methods fall under three main groups. 1. Application of a constant steady load. 2. Application of increasing loads by uniform motion of the loading mechanism. 3. Triaxial loading. [German] J.F.M.

216. A simple tensile testing machine for very fine wires. A. E. WIDDOWSON, *J. Sci. Instrum.*, 1958, **35**, 100—101. General Electric Co. Ltd., Wembley, Middlesex. A simple machine is described by which stress–strain curves can be obtained for fine tungsten wire as small as 5μ in diameter. The stress is applied and measured by the deflection of a cantilever spring, while the strain is obtained from the difference between the movement of the two ends of the test wire. Loads of up to 80 g can be applied, to give maximum extensions of about 2%. A load as small as 5 g can be measured. W.G.C.

217. An apparatus for the determination of dynamic elastic moduli at low strains. E. V. VERNON, *J. Sci. Instrum.*, 1958, **35**, 28—29. Physics Dept., Univ. of Southampton, Hants. An electronic apparatus is described for the determination, by a resonance method, of Young's modulus and rigidity modulus of materials in the form of cylindrical rods. Results can be obtained at strains as low as 10^{-5}. The method of calculation of the moduli from the observed resonant frequencies is given. W.G.C.

218. A simple laboratory method for determining the modulus of elasticity. B. E. VASSILION and C. J. BAKER, *Trans. Brit. Ceram. Soc.*, 1957, **56**, 499—508. British Ceramic Research Assn. The method is based on the accurate measurement of the deflection of a specimen under 3 or 4 point loading by optical method. Results on ceramic materials do not agree with theoretical plot derived from the Wilson-Stokes formula. B.N.

219. New method for measuring linear compressibility of solids. J. REITZEL, I. SIMON and J. A. WALKER, *Rev. Sci. Instrum.*, 1957, **28**, 10, 828—829. An apparatus involving no delicate parts is described for measuring linear compressibility of rods and tubes under hydrostatic pressures to 4000 kg/cm^2, and temperatures to 260° C. A differential transformer determines the position of a small iron cylinder attached to the specimen, thus no connections pass through the walls of the pressure chamber. Data is given for vitreous silica to an accuracy of 1%. H.J.R.

220. Some aids to the design of dies for plastics extension.—I. D. J. WEEKS, *Brit. Plast.*, April 1958, 156—160. I.C.I. Plastics, Welwyn Garden City, Herts., England. Expressions are given for calculating pressure drops in channels of various geometrics for both Newtonian liquids and plastics obeying a "power low" relation between shear stress and rate of shear. Other topics treated include shear heating and flow irregularities above a critical shear rate exhibited by a number of polymers. E.B.A.

221. Determination of grease consistency using an automatic worker consistometer. H. J. CONNORS, *Lubric. Engng.*, 1958, **14**, 22—26. Westinghouse Research Lab., Pittsburg, Pa. Describes an automatic

apparatus in which a small sample of grease is repeatedly pushed back and forth through a capillary. Curves of average rate of shear against shear stress at the wall are plotted with work input as parameter. The yield stress of a lithium-base grease, calculated from the Buckingham–Reiner equation, is found to decrease with work input. Hystersis loops in the flow curves can also be obtained. J.F.H.

222. The H.L. torsiometer : use of the instrument for measuring the setting of milk by rennet. G. W. SCOTT BLAIR, J. BURNETT and H. LILLEY, *Dairy Ind.*, 1958, **23**, 182. Nat. Inst. Res. in Dairying, Shinfield, Reading. A cylinder on a torsion wire is hung in rennetted milk in a cylindrical beaker or in the cheese vat. The torsion head rotates slowly through a small angle in alternate directions and the increasing torque on the wire is recorded. Results generally agree with U-tube gelometer. Consistency (C) is approximately linear with log time and $\log (C_\infty - C)/C_\infty$ (C_∞ is consistency after a long time) is linear with t, so that C at any time $\propto$ amount of unset casein. G.W.S.B.

VOL.
1
1958

223. New testing equipment for quality control. D. J. WEINTRITT and A. C. PERRICONE, *Bull. Amer. Ceram. Soc.*, 1957, **36**, 401—405. Baroid Division, National Lead Co., Houston, Texas, U.S.A. Plastic viscosity, yield point and gel strength of ceramic suspensions determined on a Fann V-G meter. The effects of deflocculants studied at high solids contents. B.N.

224. Creaming and other tests in the assessment of bakery fats. F. J. H. OTTAWAY, M. A. COOKSON, S. J. CORNFORD and J. B. M. COPPOCK, *J. Sci. Fd. Agric.*, 1958, **9**, No. 2, 115—122, British Baking Industries Research Association, Chorleywood, Herts., England. Attempts have been made to correlate certain properties of fats with their behaviour in cake and biscuit-baking. Penetrometer, dilatometer and creaming tests have been examined. The first two are only of limited value, but creaming can be correlated with cake volume for a type of cake whose texture depends on volume of included air, but not with the volume of biscuits in which air is included to a much more limited extent. A.

225. Ultrasonic device for measuring some physico-mechanical properties of leather, rubber plastics and materials of high molecular weight. B. G. NOVITSKII and V. M. FRIDMAN, *Akush. Zh.*, 1957, **1**, p. 92. (From *D.S.I.R. List* No. 109, April 1958, p. 2.) [Russian]

226. Determination of the fineness and consistency of ceramic glazes. R. F. MORRISON, H. C. DRAKER and H. D. CARTER, *Bull. Amer. Ceram. Soc.*, 1957, **36**, 256—260. Harshaw Chemical Co., Cleveland, Ohio, U.S.A. Consistency of ceramic slips estimated by Brookfield viscosimeter. Effects of milling time, ageing and addition of electrolytes studied. B.N.

Section C

METALS AND OTHER SOLIDS

227. Damage to solids by liquid impact at supersonic speeds. F. P. BOWDEN and J. H. BRUNTON, *Nature, Lond.*, 1958, **181**, 873—875. Physics

and Chemistry of Solids Laboratory, Physics Dept., Univeristy of Cambridge, England. A short cylinder (2 cm × 1 mm²) of liquid has been ejected at very high speeds of up to 3500 ft/sec at plane metal (stainless steel, tungsten carbide) surfaces, and the deformation observed. Water and water/glycerol mixtures were used as the deforming liquid, and the intensity of the shallow saucer-shaped depressions was found to increase with η. The deformation in the case of rigid plastics, glasses and ceramics was different from that of metals. A ring crack is produced around, and a star crack is formed below the surface of the point of impact. With the Hertz theory of contact stresses, which is used to predict regions of high tensile stress, it is possible to deduce the maximum tensile stress at the surface. Shear stresses are also caused by the high-speed (about twice the speed of impact) flow of the collapsed cylinder over the surface. W.G.C.

228. Concentrated wear of turning tools. V. SOLAJA, *Research, Lond.*, 1958, **11**, 152—156. Belgrade University, Yugoslavia. Grooving often occurs on the clearance face of turning tools. The author discusses some technological and fundamental aspects of this problem. Grooving has a considerable effect on surface finish and is a very complex phenomenon. Fatigue cracking may be a causative factor. E.B.A.

229. Mechanical and physical characteristics of jewelry bronze. D. E TROUT, *A.S.T.M. Bull.*, 1958, **227**, 45—50. Scovill Manufacturing Co., Waterbury. Conn., U.S.A. Experimental results of the effect of various degrees of cold reduction and annealing upon mechanical properties (tensile properties, hardness, elastic modulus) and also upon electrical conductivity and grain size on 87·5/12·5 copper–zinc alloy strip. A chart for converting Knoop hardness to the Rockwell B, F & 30T stress is included. E.B.A.

230. Variation of elastic constants of hardened 1% carbon steels on tempering. A. F. C. BROWN, A. G. COLE and M. F. MARKHAM, *Nature, Lond.*, 1957, **180**, 1254. Physics Division, N.P.L., Teddington, Middlesex. Two steels were tempered for 1 hr in 50° C steps between 100° and 650° C. Rigidity, G, and Young's, E, moduli were measured by the ultrasonic-pulse method, the estimated accuracy being ±0·1% and ±0·2% respectively. G was also measured by static loading, to within ±0·3%. The variations in these moduli, together with that of Poisson's ratio, with tempering temperature is shown graphically. W.G.C.

231. Effect of plastic deformation on the electrical resistivity of chromium. M. E. DE MORTON, *Nature, Lond.*, 1958, **181**, 477—478. Defence Standards Laboratories, Maribyrnong, W.3, Victoria, Australia. W.G.C.

232. The nature of unhomogeneous plastic flow of metal single crystals. E. F. SHCHUKIN *et al.*, *Dokl. Akad. Nauk SSSR*, 1958, **118**, No. 2, 277. (From *D.S.I.R. List* No. 110, May 1958, p. 23.) [Russian]

233. Dilatometric properties of Indian coals. S. SARKAR, V. V. RAO, S. C. DAS GUPTA and N. N. DAS GUPTA, *J. Sci. Industr. Res B*, 1957, **16**, 539—547. Central Fuel Research Institute, Jealgora, Bihar, India. The dilatometric properties of some Indian coals have been studied with a Sheffield Laboratory Coking Test apparatus. The characteristic temperatures and the percentage of expansion have been correlated with

the rank of coal and its coking properties. The influence of test conditions, artificial oxidation and inert contents of coals on the dilatometric behaviour has also been studied. W.G.C.

234. Relationship of Attenberg limits and cation exchange capacity to some physical properties of soil. W. R. GILL and C. A. REAVES, *Proc. Soil Sci. Soc. Amer.*, 1957, **21**, 491—495. U.S.D.A. Tillage Machinery Lab., Auburn, Ala., U.S.A. The physical properties studied are: mechanical strength, shrinkage, plastic index, modulus of rupture, compressibility, surface area and "sticky point". B.N.

235. Plasticity of graphite. H. W. DAVIDSON and H. H. W. LOSTY, *Nature, Lond.*, 1958, **181**, 1057—1059. Research Laboratories, G.E.C. Ltd., Wembley, Middlesex, England. The creep behaviour of graphite, obtained from several sources, has been examined at temperatures between 1300° and 2000° C. It was found, for a wide range of temperatures, raw materials, specimen geometries, and flexural and torsional stresses, that the creep deformation could be statistically fitted to the function

$$D_t = A + k \log_{10} t + B_t$$

where D_t is the strain at time t (min) and A, k and B are constants for each experiment. The equation is believed to relate to the structure of the graphites examined, and by repeating identical cycles of creep and recovery, the term B_t was shown to contribute to a permanent set. A relationship between K and the elastic modulus at room temperature is developed. W.G.C.

236. Elastic ice characteristics and methods of studying them. E. M. LIN'KOV, *Vestn. Len. Univers.*, 1957, **16**, 57. (From *D.S.I.R. List* No. 110, May 1958, p. 123.) [Russian]

237. Structure and elastic properties of silicate glasses. G. M. BARTENEV, *Zh. fiz. khim.*, 1957, **31**, No. 9, 1917. (From *D.S.I.R. List* No. 110, May 1958, p. 146.) [Russian]

238. Strength of glass fibres. W. F. THOMAS, *Nature, Lond.*, 1958, **181**, 1006. Engineering Laboratory, University College, Cardiff, Wales. By taking care to reduce atmospheric attack, and by avoiding mechanical damage, the tensile strength of "E" glass fibres has been measured. The coefficient of variation of breaking stress of ten test pieces has, on some occasions, been only 1%. The breaking stress has been found to be independent of the fibre diameter ($2—6 \times 10^{-4}$in), and also of the rate of drawing and of the molten glass temperature. W.G.C.

239. The effect of acid etching of well-glasses for flame proof lighting fittings. H. G. RIDDLESTONE, *Rep. Brit. Elect. Ind. Res. Ass.*, D/T 103. E.R.A., Leatherhead, Surrey. Static pressure bursting tests, thermal shock and various "impact" tests were carried out on well-glass covers for flame-proof lighting fittings. Acid etching of the surface did not significantly effect their strength. E.B.A.

240. On shear fractures of re-inforced concrete beams subject to shear and bending stresses. I. MENYHARD, *Arch. Inzyn. Ladowej*, 1957, **3** (4), 443—456. [German] P.F.

241. The morphology of fissures in concrete and reinforced concrete structures. B. BUKOWSKI, *Arch. Inzyn. Ladowej*, 1957, **3** (4), 391—442. The shape of fissures in concrete is considered and related to the various causes leading to their formation. [Polish] P.F.

242. Mechanical strength of porcelain. L. MATTYASOVSZKY-ZSOLNAY, *J. Amer. Ceram. Soc.*, 1957, **40**, 299—306. Budapest, Hungary. The mechanical strength of porcelain is influenced mainly by the stresses set up in the glassy phase. A crystalline material of higher coefficient of expansion than the glassy phase produces favourable prestresses in the glassy phase. B.N.

243. Cermets—III. Modes of fracture and slip in cemented carbides. N. M. PARIKH, *J. Amer. Ceram. Soc.*, 1957, **40**, 335—339. Ford Motor Co., Dearborn, Michigan, U.S.A. Fracture and slip patterns in cemented carbides are determined by the relative surface energies of various phases. These are discussed in terms of the role of the metal film surrounding the carbide grains. B.N.

244. Plastic deformation of phenolphthalein at 50,000 atmospheres. H. A. LARSEN and H. G. DRICKAMER, *J. Phys. Chem.*, 1958, **62**, 119. Department of Chemistry and Chemical Engineering, University of Illinois, Urbana, Illinois, U.S.A. Solid, white, powdered phenolphthalein is first compressed between two flat pistons to pressures in the range 20,000 to 50,000 atmospheres. The sample is then sheared by rotating one of the pistons, and turns red. A chemical reaction is proposed to explain the colour change. A.S.L.

Section D

POLYMERS, ELASTOMERS AND VISCOELASTIC MATERIALS

245. Behaviour of rubber in compression under dynamic conditions. H. MCCALLION and D. M. DAVIES, *Rubb. Chem. Technol.*, 1957, **30**, 1045 ; *Proc. Inst. Mech. Engrs.* 1955, **167**, 1125. Department of Engineering, University of Nottingham. Experimental data are given on the dynamic mechanical properties of a black filled rubber in uni-directional compression in the ranges : frequency 1·33—1200 c/min, strain amplitude 0—10%, temperature −60° to 125°C. An attempt has been made to develop relations to describe the dynamic mechanical properties of rubberlike materials. Sixteen pages of comments and discussion are appended. D.W.S.

246. Frictional temperature rises on rubber. A. SCHALLAMACH, *Rubb. Chem. Technol.*, 1957, **30**, 1097. British Rubber Producer's Research Association, Welwyn Garden City, Herts., England. Frictional temperature rises and frictional forces on rubber at velocities up to about 400 cm/sec and under various normal loads have been determined by employing a thermojunction as slider. In the experimental velocity range, the frictional temperature rises increase approximately proportional to the square root of the sliding velocity. The finite heat conductivity of the

slider has been found not to affect the results materially. The temperature rises when plotted against the dissipated frictional energy lie on closely grouped curves. Coefficients of friction as a function of load and velocity are given. Author

247. Changes in specific volume on stretching rubber. A. B. KUSOV, V. I. TROFIMOVA and YU. I. NILOVA, *Kolloidnyĭ Zh.*, 1957, **19**, 587. Leningrad Inst. of Technol., Dept of Synthetic Rubber Technology. At optimum elongation, volume increased by 2%. Volume-stretch curves are S-shaped, with inflexion at same stretch as that in load-stretch curves. At very large elongations, crystallization produces small decreases in volume. [Russian]. G.W.S.B.

248. The dependence of the elasticity of finished rubbers on the molecular weight of the original stock. L. S. PRISS, *Kolloidnyĭ Zh.*, 1957, **19**, 607. Institute of Scientific Investigations in the Tyre Industry, Moscow. An exact account has been made of the number of effective molecular chains in the vulcanizate network formed by a monodisperse rubber and a rubber with a molecular weight distribution following Poisson's law. The correction for the initial molecular weight was found to depend upon the character of distribution only for relatively sparse networks. The Flory equation $C = 2\nu_0(1 - 2M_c/M)$ contains an error and should be replaced by the equation $C = 2\nu_0(1 - M_c/M)$. The possibility has been indicated of applying the formulas obtained to the analysis of the mechanism of oxidative destruction and chemical relaxation. [Russian] Author

VOL.
1
1958

249. The relationship between the intrinsic viscosity and the molecular weight of Buna-S. CHEN-JEN-YUAN, CHING-WEN and CHENG-YUNG-SHIH. *Kolloidnyĭ Zh.*, 1957, **19**, 515. Chinese Inst. of Practical Chemistry, Chanchun', China. The molecular weights of nine fractions of Buna S. were determined osmometrically in toluene. The intrinsic viscosity $[\eta]$ is related to molecular weight (M) by the equation :

$$[\eta] = 1{\cdot}65 \quad 10^{-4}\, M^{0{\cdot}78}$$

[Russian] G.W.S.B.

250. On the external friction of rubber. V. V. LAVRENT'EV, *Kolloidnyĭ Zh.*, 1957, **19**, 522 (letter). Potemkin City of Moscow Pedagogue Inst., Dept. of Theoretical Physics. Equations of Thirion and of Bartenev relating reciprocal of limiting coefficient of friction to load are compared. At all but smallest loads, both equations fit the data. At small loads, Bartenev's equation follows curvature of the data while Thirion's remains linear. [Russian] G.W.S.B.

251. The stress-strain behaviour of natural rubber. F. H. MULLER, *Rubb. Chem. Technol.*, 1957, **30**, 1027 ; *Kautsch. u. Gummi*, 1956, **9**, WT 197. Laboratory for high Polymers, University of Marburg, Germany. The differences between adiabatic and isothermal stress–strain relations are discussed. Heating during deformation occurs because of frictional losses and changes in entropy and results in a rise in temperature of the sample. The changes in temperature can have a marked effect on the observed stress–strain relations, e.g. necking phenomena in cold-stretching. The magnitudes of these effects are discussed. A.K.

252. Influence of interaction of molecules, cross linking and temperature on the destruction and time dependence of strength of caoutchouc like polymers. G. M. BARTENEV *et al.*, *Zh. tekh. fiz.*, 1958, **28**, No. 2, 287. (From *D.S.I.R. List* No. 110, May 1958, p. 157.) [Russian]

253. Elastoviscous and plastic flow of bulk Hevea rubber under moderate stresses, 1 and 2. CHIEN PAO-KUNG YU FU-SEN and YU PAO-SHAG, *Sci. Sinica.*, 1957, **6**, 863—880. [Chinese]

254. Dynamic viscosity and shear modulus of molten polystyrene. W. P. COX, L. E. NIELSEN and R. KEENEY, *J. Polym. Sci.*, 1957, **26**, 365. Research Dept., Plastics Division, Monsanto Chemical Co., Springfield, Mass., U.S.A. The dynamic mechanical properties of several polystyrene fractions were measured in ranges 0·05 to 5 c/sec and 160—220° C. Data obtained were superposed by means of Ferry's reduced variables. The empirical temperature shift factors involved in this superposition agreed well with values calculated from William's universal function. The observed molecular weight dependence agreed qualitatively with Rouse's theory as modified by Ferry, Landel and Williams for application to polymer melts. Author

255. Crystallinity and orientation in silicone rubber—II. Physical measurements. E. L. WARRICK, *J. Polym. Sci.*, 1958, **27**, 19. Dow Corning Corporation, Midland, Mich., U.S.A. Density and X-ray data for silica-filled dimethylpolysiloxane rubber give incipient crystallization temperatures and the form of the crystal growth. Stress-relaxation data at several temperatures show that whilst tension decreases with temperature the materials are far from being ideal rubbers. Both filled and unfilled samples show thermo-elastic inversion effects. Crystallization of stretched samples of these materials is accompanied by an increase in tension, but no overall increase in orientation of chain segments. This is discussed with reference to the opposite effects shown by natural rubber. D.W.S.

256. Intrinsic viscosity and molecular weight of styrene polymerised catalytically by di- and tri-chloracetic acid. C. P. BROWN and A. R. MATHIESON, *J. Chem. Soc.*, 1957, 3620–3624. The University, Nottingham. Intrinsic viscosity $[\eta]$ of polymers in C_6H_6 solution at 25° C is related to the cryoscopic mol. wt. M by $[\eta] = 5{\cdot}2 \times 10^{-4} M$. W.H.B.

257. The dependence of the viscosity of butadiene-butastyrene rubbers on their structure. A. S. NOVIKOV and F. S. TOLSTUKHINA, *Kolloidnyĭ Zh.*, 1957, **19**, 599. Institute of Scientific Investigations of the Synthetic Rubber Industry, Moscow. Measuring the shear of a layer of polymer under approx. Newtonian conditions, viscosity is found to be linear with a power of molecular weight. The activation energy was determined over a range of 24—82° C. [Russian]. G.W.S.B.

258. Studies on straining of high polymer solids. K. ITO, *J. Polym. Sci.*, 1958, **27**, 419. Division of Engineering, Brown University, Providence 12, R.I., U.S.A. The stress–strain relations in compression for specimens of epoxy cast resin and hard P.V.C., have been measured for undeformed samples and samples oriented by compression. The effect of annealing on the stress–strain relations has been investigated. D.W.S.

259. Viscoelasticity of some cross-linked polymers. N. TOKITA and K. KANAMARU, *J. Polym. Sci.*, 1958, **27**, 255. Dept. of Chemistry, Duke University, North Carolina, U.S.A. The dynamic moduli and losses in filaments of cross-linked viscose rayon and acetate rayon were investigated as functions of the temperature and degree of cross-linking for frequencies in the range 0·05 to 1070 c/sec. The results are discussed in terms of the affect of the " long chain cross-links " on motion of the molecular chains. D.W.S.

260. Theory of viscoelasticity of amorphous polymers. Part 2. Time-temperature reducibility of relaxation and retardation spectra. O. NAKADA, *J. Phys. Soc., Japan*, 1957, **12**, 1218—1225.

261. Structure and viscoelastic properties of thermoplastic materials. A. RODEYNS, *Industr. chim. belge*, 1957, **22**, 1275—1286. [French]

VOL.
1
1958

262. Determination of constants in the intrinsic viscosity-molecular weight equation. A. SHARPLES and H. M. MAJOR, *J. Polym. Sci.*, 1958, **27**, 433. (British Rayon Research Association, Heald Green Laboratories, Wythenshawe, Manchester, 22, England.) The constants in the modified Staudinger equation are usually found by preparing a monodisperse fraction of polymer. An alternative method is suggested in which the known molecular weight distribution is used. The method has been applied to the case of cellulose triacetate in chloroform. D.W.S.

263. Influence of rate of shear on the apparent viscosity of dilute polymer solutions. T. TAKEMURA, *J. Polym. Sci.*, 1958, **27**, 549. (Dept. of Applied Sci., Faculty of Engng, Kyushu Univ., Kyushu, Japan.) The measured viscosity of polymer solutions varies with the magnitude of the applied shearing stress. In this paper a modified Rouse model of a polymer molecule (which has some stiffness) is used, and the diffusion equation is solved with respect to the coordinate system moving with the polymer molecule. Results indicate that the above phenomena is a natural consequence of the fact that the molecules are caused to rotate by the shearing action. A.K.

264. Viscosity of dilute solutions of long chain polymers. H. L. BHATNAGAR, A. B. BISWAS and M. K. GHARPUREY, *J. Chem. Phys.*, 1958, **28**, 88—90. National Chemical Laboratory, Poona, India. An expression for the relative viscosity η_r has been obtained on the basis of the " theory of rate processes " using an " equivalent sphere " model, which relates η_r to parameters such as shearing force, absolute temperature, and the volume fraction of the polymer. In the limit of zero rate of shear, a relation between the Flory constant ϕ and Huggin's constant k'' has been obtained. Some important applications of the derived equations have been discussed. A.

265. Dynamics of chain molecules in dilute solutions, with special reference to non-Newtonian viscosity. R. CERF, *Nature, Lond.*, 1958, **181**, 558—559. Centre de Recherches sur les Macromolécules, 6 rue Boussingault, Strasbourg, France. The theoretical curves of polyisoprene, giving the intrinsic viscosity as a function of the velocity gradient, are shown to be in reasonable agreement with the experimental curves, and thus can be used to explain a large number of facts (cf. Rheology Abstracts, December 1957, Bulletin 53, p. 6, Nos. 3624, 3625). W.G.C.

266. New data on the orientation of birefringence in a flow of polymer solutions. E. G. FRISMAN, *Dokl. Akad. Nauk SSSR*, 1958, **118**, No. 1, 72. (From *D.S.I.R. List* No. 110, May 1958, p. 19) [Russian]

267. The effect of the addition of plasticizer on the mechanical properties of compatible polymers of vinyl chloride with vinyl chloride and of polyvinyl chloride. R. I. FELD'MAN, A. K. MIRONOVA and S. I. SOKOLOV, *Kolloidnyi Zh.* 1958, **20**, 106. Moscow Institute of Technol. for Light Industries, Moscow. The previously established addivity of the logarithms of such quantities as the tensile strength and moduli in the system polymer-plasticizer in the high-elastic state has been tested and confirmed on the example of a copolymer, the calculations being made on a molar fraction basis. A comparison of the results obtained with the previous data gave support to the views on the effect of the plasticizer on polymers of a polar character developed by the authors in preceding papers. The limiting values of the individual characteristics (tensile strength and the moduli) obtained by extrapolation to the pure component maintain constant values within the limits of experimental error, irrespective of the other components of the system. [Russian] Author

268. Discontinuity in the flow curve of polyethylene. E. B. BAGLEY, I. M. CABOTT and D. C. WEST, *J. Appl. Phys.*, 1958, **29**, 109—110. Canadian Industries Ltd., McMasterville, Quebec, Canada. In extrusion experiments using a linear polyethylene it was found that there is a pressure region in which the output is double-valued and the extruded filaments can be smooth or rough according to the output value. G.H.T.

269. Effect of thermal history on the dynamic modulus at 20° C of irradiated polyethylene. A. E. WOODWARD, C. W. DEELEY, D. E. KLINE and J. A. SAUER, *J. Polym. Sci.*, 1957, **26**, 383. College of Chemistry and Physics, Pennsylvania State University, Pennsylvania, U.S.A. Data are presented to show the effect of heating on the density and dynamic modulus at 20° C of samples of polythene cross-linked by irradiation. Comparison with data obtained by other workers reveals significant differences. These are attributed to differences in temperature during irradiation. D.W.S.

270. Stress relaxation and dynamic properties of ethylene polymers. E. T. OSKIN and B. MAXWELL. Order PB 121924 from O.T.S. U.S. Dept. of Commerce, Washington 25, Princeton University. Linear and normal polyethylene are compared using standard relaxation methods and a dynamic mechanical test. The effects of stress, time and temperature were studied. (Reduced abstract from *Plastics Technology*, 1957, p. 936.) E.B.

271. Weight average molecular weight and intrinsic viscosity of linear polyethylene. J. T. ATKINS, L. T. MUUS, C. W. SMITH, E. T. PIESKI, *J. Amer. Chem. Soc.*, 1957, **79**, 5089—5091. E. I. du Pont de Nemours Inc., Wilmington, Delaware, U.S.A. The weight-average mol. wt. M_w obtained from light scattering measurements was related to the intrinsic viscosity $[\eta]$ in chloronaphthalene at 125° C by

$$[\eta] = 4{\cdot}3 \times 10^{-4} M_w^{0{\cdot}67}$$ W.H.B.

272. Investigation of the mechanical properties of polyethylene and paraffin by the compound vibrator method. I. G. MIKHAILOV and V. A. SOLOV'EV, *Akusti. Zh.*, 1957, No. 1, 65. (From *D.S.I.R. List* No. 109, April 1958, p. 1.) [Russian]

273. The low temperature transition in polytetrafluoroethylene. N. G. MCCRUM, *J. Polym. Sci.*, 1958, **27**, 555 (letter). Polychemicals Dept., Du Pont Experimental Station, Wilmington, Delaware, U.S.A. Measurements of internal friction and dynamic modulus on four samples of polytetrafluoroethylene of different crystallinities show that there is a low temperature transition at ca. $-100°$ C in this polymer and that it occurs in the amorphous regions. D.W.S.

274. Investigation of the relaxation of extension of textile fibres. G. N. KUKIN and A. N. SOLOWJEW, *Faserforschung*, 1958, **9**, 21—30. Moscow Textile Institute. Creep and recovery data are presented for cotton, linen, wool, viscose and high-tenacity viscose, fibres. The data are fitted empirically to expressions involving sums of three exponential functions of time. [German] A.S.L.

275. Mechanics of elastic performance of textile materials—XIII. Torque development in yarn systems—Singles yarns. M. M. PLATT, W. G. KLEIN and W. J. HAMBURGER, *Text. Res. J.*, 1958, **28**, 1. Fabric Research Labs., Inc., Dedham, Massachusetts, U.S.A. This paper is the first of a series which will deal with torque in textile systems. It is concerned principally with the analysis of torque developed in twisted singles yarns as created by (a) fibre bending, (b) fibre torsion, and (c) bending and torsion in combination. Equations are developed, using elastic theory, relating singles yarn torque to fibre elastic properties, fibre geometry, and singles yarn structure. Author

276. On the stress relaxation of nylon 6. T. YOSHITOMI, K. NAGAMATSU and K. KOSIYAMA, *J. Polym. Sci.*, 1958, **27**, 335. Dept. of Applied Science, Faculty of Engineering, Kyushu University, Fukuoka, Japan. The stress relaxation of filaments of low crystallinity nylon 6 were measured at three relative humidities by a torsional method. The results at 0% and 75% R.H. are reduced to a single master curve by an extension of Ferry's methods. An approximate relaxation time spectrum is obtained. D.W.S.

277. Notes on the cold drawing of polyethylene terephthalate. S. NEWMAN, *J. Polym. Sci.*, 1958, **27**, 563 (letter). Monsanto Chemical Co., Plastics Division, Springfield, Massachusetts, U.S.A. The temperature at the neck which forms during cold drawing of polyethylene terephthalate is estimated by comparison of the drawing characteristics with the measured dynamic modulus and loss factor at higher temperatures. The figure obtained agrees well with other estimates obtained by different methods. The stability of the process is discussed. D.W.S.

278. The measurement of hydroxyl and carboxy end groups in polyethylene terephthalate. I. M. WARD, *Trans. Farad. Soc.*, 1957, **53**, 1406—1412. I.C.I. Fibres Division, Hookstone Road, Harrogate, Yorks. The application of the method to find the number average molecular

weight is discussed and the results given for samples of different intrinsic viscosity, $[\eta]$ which is related to number average molecular weight by

$$[\eta] = 3{\cdot}4 \times 10^{-4} M_w^{0{\cdot}77}$$ W.H.B.

279. The influence of heat treatment on the properties of polycaprolactam fibres. G. BODOR, *Faserforschung*, 1957, **8**, 521—523. Műanyagipari Kutató Intézet, Budapest. Nylon filaments, rapidly cooled to $-60°$ C after spinning, are heated for 30 min at temperature T and again cooled to $-60°$ C. The effect of varying T in the range 10° C to 200° C is studied in measurements of dye-uptake, elastic recovery, refractive index, knot-strength, and Young's modulus. Data are given for draw-ratios 0, 2·5. [German] A.S.L.

280. Photo-elastic effect in methyl-methacrylate and poly-*p*-tertiary butylphenylmethylacrylate polymers and their copolymers. V. N. TSVETKOV *et al.*, *Zh. tekh. fiz.*, 1958, No. 1, 97. (From *D.S.I.R. List* No. 109, April 1958, p. 150.) [Russian]

281. Dielectric and dynamic properties of poly(methylmethacrylate). R. KONO, *Chem. High Polymers, Japan*, 1957, **14**, 500—503. [Japanese] English summary 503.

282. Mechanical properties of solutions of methacrylate polymers. D. M. STERN, *Diss. Abs.*, 1957, **17**, 2173.

283. Chemorheological study of polyurethan elastomers. P. C. COLODNY and A. V. TOBOLSKY, *J. Amer. Chem. Soc.*, 1957, **79**, 4320—4323. Frick Chemical Lab., Princeton University, N.J., U.S.A. Two series of polyurethan elastomers were prepared which contained (a) predominantly urethan linkages and (b) equal numbers of urethan and substituted urea or biuret groups. The chemorheology of these samples was investigated by stress relaxation experiments. It was found that the urethan linkages underwent scission at a rate one-tenth that of the combined rate of the substituted urea and biuret groups. A.

284. Laboratory scale evaluation of the polymer from 3 : 3-bischloromethyl oxa*cyclo*butane. D. J. H. SANDIFORD, *J. Appl. Chem.*, 1958, **8**, 188–196. I.C.I. Plastics Division, Welwyn Garden City, Herts., Eng. A wide range of properties are investigated, including melt viscosity (capillary penetrometer) volume-temperature relations, dynamic elastic properties and electrical properties. E.B.A.

285. Determination of the flow properties of thermoplastic melts. J. M. MCKELVEY, J. GAUIS and T. G. SMITH, *S.P.E.J.*, 1957, **13**, No. 9, 29. A review of methods and instruments for measuring the flow properties of extremely viscous fluids, with particular reference to problems peculiar to thermoplastic melts. (Abstract from *Plastics Technology*, 1957, p. 1023.) E.B.

286. A thermal-mechanical study of epoxide resins. L. I. GOLUBENKOVA, B. M. KOVARSKAYA, M. S. AKUTIN and G. L. SLONIMSKII. *Kolloidnyi Zh.*, 1958, **20** (1), 34. Institute for Scientific Research and Development in Plastics, Moscow. Depending upon the ratio of the initial diphenyl and epichlorohydrine components epoxide resins may be either thermoplastic or thermoreactive. Solidified epoxide resins have tri-dimensional structures

the mechanical behaviour of which is connected with the epoxide group content of the initial product. Thus resins with lower numbers of epoxide groups are more elastic at elevated temperatures than those with higher numbers. [Russian] Author

287. Change of the mechanical behaviour of phenol-formaldehyde resin during condensation. K. OGINO, *J. Chem. Soc. Japan*, 1957, **78**, 1622—1625. [Japanese]

288. Rapid determination of the intrinsic viscosity of cellulose nitrate. P. F. DAVISON, *Tappi*, 1957, **40**, 975—977. Makes use of the Schulz-Blaschke equation with an empirical correction for shear dependence of viscosity. R.H.B.

289. Compatibility of nitrocellulose and butadiene copolymers—IV. Relaxation behaviour of binary mixtures. S. S. VOYUTSKII, V. I. ALEKSEENKO and L. E. KALININA, *Kolloidnyĭ Zh.*, 1958, **20**, (1), 20. Central Institute for Scientific Research in Leather Substitutes, Moscow. Relaxation velocity increases with increasing copolymer content. The limiting relaxation time, characterizing the time between two individual molecular rearrangements, is independent of the degree of deformation only when mixtures are reasonably homogeneous. The activation energy of relaxation is the same for all the copolymers : 10·7 kcal/mole. [Russian] G.W.S.B.

VOL. 1 1958

290. The hydrodynamic characteristics and polydispersity of some samples of ethyl cellulose. T. I. SAMSONOVA and S. YA. FRENKEL', *Kolloidnyĭ Zh.*, 1958, **20** (1), 67. U.S.S.R. Institute of High-molecular Compounds, Leningrad. Oxidation is accompanied by depolymerization (resulting in loss of strength) and a change in polydispersity. In ethyl acetate, the intrinsic viscosity $[\eta]$ and sedimentation constant (s_o) are related to molecular weight (M) as follows: $[\eta] = 2{\cdot}82 \times 10^{-5} M$ dl/g: $s_o = 4{\cdot}6 \times 10^{-2}$. $M^{1-0{\cdot}62}$ Svedberg units. The effective length of the ethyl cellulose chain unit in ethyl acetate is 25 Å ; twice as great as in nitrocellulose. [Russian] G.W.S.B.

291. Application of statistical theory of elastomers to supercontracted keratin fibres. A. R. HALY and M. FEUGHELMAN, *Text. Res. J.*, 1957, **27**, 919. Physics and Engineering Unit, Wool Textile Research Labs., C.S.I.R.O., The Hermitage, Ryde, N.S.W., Australia. Keratin fibres in lithium chloride solutions undergo supercontraction in two distinct stages. Evidence is presented which suggests that the stress-strain behaviour of immersed fibres, at either stage of supercontraction, is rubber-like. The relation of the mechanical behaviour to molecular structure is discussed. D.W.S.

292. A fundamental investigation of adhesion—II. Method for measuring shrinkage stress in restrained gelatin films. R. C. WEATHERWAX, B. COLEMAN and H. TARKOW, *J. Polym. Sci.*, 1958, **27**, 59. Forest Products Lab., Forest Service, U.S. Dept. of Agriculture, Madison, Wisconsin, U.S.A. Gelatin solutions shrink as water evaporates from the gel. If the shrinkage is prevented, tensile stresses develop. A technique is described for measuring the tensile stress developing in the plane of edge-clamped gelatin films during drying. It is based on measurement of the elastic deformation of the film when stressed normally to the plane of the

film. A stress of 4000 lb/in² was observed in a dried gelatin film. The reality of the stress was confirmed in a completely independent manner. Author

293. Hydrodynamic configuration of cellulose acetate—I. Viscometric study. G. M. GUZMAN and J. M. G. FATOU, *An. Soc. esp. Fis. Quim. B.*, 1957, **53**, 669—684. [Spanish] English summary, 669.

294. Viscoelasticity of cellulose derivative films—III. Second-order transition point of cellulose nitrates. K. NAKAMURA and T. OOKAWA, *Chem. High Polymers, Japan*, 1957, **14**, 544—550. [Japanese] English summary, 550.

OL.
1
958

Section E

PASTES AND SUSPENSIONS

295. An application of the method of approximations to the calculation of flow of dispersed systems. N. V. TYABIN and G. V. VINOGRADOV, *Kolloidnyĭ Zh.*, 1957, **19**, 505. Mineral Oil Institute, Moscow. The necessity of accounting for the actual values of the maximum tangential stresses and velocity gradients in approximating the flow curves of disperse systems has been illustrated on greases and bitumens. Expressions have been derived for the angular momentum of flow of a plastic disperse system in an annular space between two coaxial cylinders, the flow curve of the system being capable of approximation by n Shvedov–Bingham equations. The laws governing the velocity distribution for the flow of a Newtonian liquid along an inclined surface have been determined. The flow curve for a Newtonian liquid has been approximated by two Newtonian and two Shvedov–Bingham equations. [Russian] Author

296. The influence of electrolytes on the structural-mechanical properties of bentonite suspensions. I. A. USKOV, *Kolloidnyĭ Zh.*, 1957, **19**, 511. Kiev State Univ., U.S.S.R. Aqueous suspensions of dialysed " askangel " (bentonite), treated with various electrolytes, were studied in a concentric cylinder viscometer. Effects are rapid during the first 24 hr, then much slower but continue for a month. The different ions are compared. [Russian] G.W.S.B.

297. The orientation of clay particles in the process of deformation of clay pastes. V. S. FADEEVA, *Kolloidnyĭ Zh.*, 1957, **19**, 640. Institute for Scientific Investigations in Constructional Ceramics, Moscow. A microscopic study of specimens of plastic clay masses subsequent to their deformation carried out with the aim of elucidating the causes for the separation of ceramics into layers during the compression process showed that the deformation of these masses is accompanied by three dimensional orientation of the particles which takes place chiefly along the direction of the yield stress. [Russian] Author

298. Adherence and viscosity of blood contacting foreign surfaces, and the plasmatic zone in blood circulation. A. L. COPLEY, *Nature, Lond.*, 1958, **181**, 551—552. Medical Research Labs., Charing Cross Hospital

London, W.C.2. Blood, plasma and serum are found to adhere to glass tubes after passage of these fluids, and that with higher velocities of flow more of the fluid adhered. Similar effects were observed with other surfaces. W.G.C.

299. Changes in structure, degree of dispersion and limiting shear-stress of peats on freezing. M. P. VOLAROVICH, K. F. GUSEV, S. N. MARKOV and V. P. TROPIN, *Kolloidnyĭ Zh.*, 1957, **19**, 401. Moscow Peat Institute. In process of freezing peat, bound water is liberated and sedimentation analysis also reveals considerable coagulation. The limiting shear-stress, as measured with a cone-plastometer, is less for thawed peat than for the unfrozen material. X-ray diffraction maxima also disappear with freezing. [Russian] G.W.S.B.

300. Mechanical tests on road surfacing mixtures—II. Stability tests on rolled asphalt. D. C. BROOME and A. PLEASE, *J. Appl. Chem.*, 1958, **8**, 121—135. Road Research Laboratory, Harmondsworth, Middlesex, Eng. A comparison of resistance to deformation of rolled asphalt has been made at 45° using eight mechanical tests. The compositions tested conformed to B.S. 594 and the comparison showed that these cover a wide range of stability. Some rich plastic mixtures included in B.S. 594 although rejected after mechanical tests can be used successfully on the road. Dynamic loading tests employing pressures experienced on the road appear to give the best relative assessment of stability for the compositions best suited to conditions in Great Britain. Author

301. Viewpoints on the evaluation of bitumens. D. C. BROOME, *Bitumen, Teere, Asphalte u. Peche*, 1958, **9**, 40—43. Limmer and Trinidad Wharf, London, S.W.6. Presents reasons why conventional test methods do not give the complete information for a bitumen and considers how additional information can be obtained. Tests discussed include penetration, ductility, penetration index, viscosity, plasticity number, stiffness, breaking point. Reasons are given for the preference for certain tests over others. Some tests should have less limited conditions than normally specified. For example, penetration and ductility should be measured not at a single temperature but as a function of temperature. [German] T.F.H.

302. Physical properties of thin bitumen films. C. MACK, *Bitumen, Teere, Asphalte u. Peche*, 1957, **8**, 350—351. Since bitumen is often used in the form of thin films, for example in films between the stones of a road-surfacing aggregate, it is not sufficient to measure physical properties on bulk samples only. Film strength (F) is measured in the separation of two steel plates held together by a bitumen film. The graph of F against film thickness passes through a maximum the maximum value correlating with the surface tension of the bitumen. Examples are given showing the relation between F and the behaviour in practice of road-surfacing aggregates. [German] J.F.H.

303. Mixtures of petroleum bitumen with Trinidad asphalt. Dr. STEINHILBER and Dr. SCHIROTT, *Bitumen, Teere, Asphalte u. Peche*, 1957, **8**, 360—361. Results are given of measurements of softening point, penetration, breaking point, ductility and flow behaviour before and after heating to 163° C. No improvement is observed following the addition of the Trinidad asphalt. [German] T.F.H.

304. A study in paint vehicles—I. L. DINTENFASS, *J. Oil Col. Chem. Ass.*, 1957, **40**, 761—784. Taubmans Industries Ltd., St. Peters, N.S.W., Australia. The viscosities of a number of oils, resins and paint vehicles in various solvents are related to their solvent power, which also controls the degree of thixotropy and dilatancy. A theory is developed. Skinning, gelation are discussed. W.H.B.

305. The determination of the fluidity of ceramic slips. N. K. ANTONEVICH, *Steklo I Keramika*, 1957, **14**, No. 12, 17. (From *D.S.I.R. List* No. 110, May 1958, p. 97.) [Russian]

306. Flow properties and structure of peptized aluminium soap-hydrocarbon gels. W. H. BAUER, N. WEBER and S. E. WIBERLEY, *J. Phys. Chem.*, 1958, **62**, 106—110. Rensselaer Polytechnik Institute, Troy, New York, U.S.A. Solutions in toluene containing more than 1% by weight of aluminium hydroxydilaurate exhibit at shear rates less than $0{\cdot}01\ sec^{-1}$ a large constant viscosity and elastic recovery ; at higher shear rates, the viscosity is greatly reduced and markedly dependent on shear rate. This behaviour is attributed to the existence, at low shear rates, of a network structure which breaks up at high shear rates. The present paper shows that addition of small amounts of a peptizer, *m*-cresol, reduces the viscosity and elastic molulus at low shear rates and reduces the critical shear rate above which the viscosity is variable ; it is suggested that the peptizer weakens the associations between solute molecules. "Activation energies", estimated from viscosity values at different temperatures, gave qualitative support to this picture. A.S.L.

307. Shear strength of two sided films and surface layers in saponin solutions. K. V. ZOTOVA *et al.*, *Dokl. Akad. Nauk SSSR*, 1957, **117**, No. 5, 833. (From *D.S.I.R. List* No. 110, May 1958.) [Russian]

308. The processes of the formation of structure in milk fat and their significance in the manufacture of butter. A. I. TITOV*, I. N. VLADOVETS and P. A. REBINDER, *Kolloidnyĭ Zh.*, 1958, **20**, 92. *All-Union Scientific Research Institute of the Dairy Industry, Moscow. Milk fat is sheared in a Höppler consistometer in which a plunger (? spherical) is forced through the butter contained in a cylinder. Creep curves are derived for a series of stresses, which clearly differentiate an immediate strain from a combination of elastic creep and flow. Flow curves, plotting shear-rate against stress (0—10 kg/cm^2) for a series of temperatures (2·5—17·5°C) show evidence of yield-values and, except perhaps at the highest temperatures, are markedly curved. Three curves showing rates of change of yield-value, plastic viscosity and apparent viscosity with temperature can be made unique by a suitable scaling of these properties. Scatter curves show a high correlation between rate of cystallization of butter-fat and apparent viscosity. Following Mulder's theories, the importance of the temperature of crystallization and also of mechanical treatment during the hardening process in controlling butter consistency, are stressed. A comparison is made between batch- and continuous-processes of butter-making. [Russian] G.W.S.B.

309. The consistency of starch-milk puddings—I. R. RUTGERS, *J. Sci. Fd Agric.*, 1958, **9**, 61—68. Laboratory Royal Mills, Laan Bros., Wormerveer, Holland. A standardized procedure for the preparation of

starch-milk puddings is evolved and a study is made of various types of apparatus for the determination of the viscosity and consistency of the products. The limitations and applications of the instruments are discussed. Author

310. The consistency of starch-milk puddings—II. R. RUTGERS, *J. Sci. Fd Agric.*, 1958, **9**, 69—77. Laboratory Royal Mills, Laan Bros., Wormerveer, Holland. The consistency of starch-milk puddings is discussed with reference to the cooking temperatures of the puddings, composition of the cooking liquid, cooling conditions after cooking, temperature of storage, and sterilization. The effects of the concentration of maize starch and the use of starches other than maize are also examined. Author

311. Physical properties of noodles. T. SHIMIZU, H. FUKAWA, and A. ICHIBA, *Cereal Chem.*, 1958, **35**, 34—46. Central Laboratory of Nisshin Flour Milling Co., Tokyo, Japan. Typical noodles from Japanese domestic wheat flour exhibited instantaneous elasticity of the order of 10^5 dyn/cm², a viscous flow of about 10^8 poises, and a retarded elasticity under constant load. The elastic modulus decreased with increase in temperature, which indicates that both entropy and internal energy changes occurred when noodles were deformed. The elastic modulus, breaking energy, and stress relaxation increased with increases in crude protein content and boiling time. The gluten network plays an important role in a gelatinized and denatured dough. A.

VOL.
1
1958

Section F

LIQUIDS

312. Unsteady flow of viscous fluid between parallel porous walls. D. E. DOLIDZE, *Dokl. Akad. Nauk SSSR*, 1957, **117**, No. 3, 380. (From *D.S.I.R. List* No. 109, April 1958, p. 19.) [Russian]

313. Ultrasonic absorption in viscous liquids. I. G. MIKHAILOV, *Akust. Zh.*, 1957, No. 2, p.177. (From *D.S.I.R. List* No. 109, April 1958, p. 3.) [Russian]

314. Experimental investigation of railroad journal bearing operating characteristics. A. L. BUSBY and G. L. PIGMAN, *Lubric. Engng*, 1957, **13**, 546—550. Douglas Aircraft Co., Santa Maria, Calif., U.S.A. It is shown that measured friction and oil flow data are in reasonable agreement with values computed from the theory of partial journal bearings based on the assumption that the oil film cavitates. Values computed from the theory based on the assumption that the film is complete and has a negative pressure region deviate considerably from the measured data under conditions of high loading. J.F.H.

315. Studies on the influence of surface tension and contact angle on the displacement of oil by water in porous substances. W. V. ENGELHARDT and H. LÜBBEN, *Erdöl u. Kohle*, 1957, **10**, 747—752, 826—830. Gewerkschaft Elwerath, Hanover. In the first part deductions are made from existing

theory concerning the importance of boundary surface forces for the mutual displacement of immiscible phases in porous media. The present work is limited to consideration of displacement in relation to contact angle and surface tension in simple model systems without examining separately the spatial and time variations of saturation and relative oil flow. It was desired first to determine how the displacement of oil by water is qualitatively influenced by the boundary surface conditions and in what manner a practical utilisation of this phenomena appears to be possible. In the experiments described the displacing water is pressed at a constant rate into the oil-filled porous system and the out-flowing quantity of oil and water is measured. In the second part the experimental results are discussed. [German] J.F.H.

316. Physical properties of neutral sulphite spirit liquors. S. T. HAN, *Tappi*, 1957, **40**, 921—926. Includes data obtained with Ostwald and Brookfield viscometers. R.H.B.

317. This equation gives viscosity. L. F. ALBRIGHT and K. K. INNES, *Petrol Refin.*, 1957, **36**, 155—158. The viscosity of normal paraffins are shown to fit the equation $\eta = A.T^n e^{B/T}$. The constants A, B and n have been calculated from the data tabulated by the American Petroleum Institute. (Project No. 44). All the normal hydrocarbons up to C^{20} have been dealt with. It is claimed that using these constants the viscosity, over a wide range of temperature, can be predicted to within an accuracy of seven per cent. Some other hydrocarbons have been dealt with in a similar manner. A.D.B.

318. Discrete ion theory and viscous flow in liquid silicates. J. D. MACKENZIE, *Trans. Farad. Soc.*, 1957, **53**, 1488—1493. Univ. Chem. Lab., Lensfield Road, Cambridge, Eng. Viscosities of $LiO_2 + Na_2O + SiO_2$, $Na_2O + K_2O + SiO_2$, $Na_2O + CaO + SiO_2$, $Na_2O + BaO + SiO_2$ Linear dependence of $\log \eta$ and $1/T$ in range 900°—1400° C, gives activation energies, 36—43 kcals/mole. From results for binary melts a discrete ion theory for liquid silicates is postulated. W.H.B.

319. Molecular constants and macro-physical properties of mixtures. I. Viscosity of liquid binary mixtures. A. E. LUTSKII and E. M. OBUKHOVA, *Zh. fiz. khim.*, 1957, **31**, No. 8, 1693. (From *D.S.I.R. List* No. 109, April 1958, p. 138.) [Russian]

Section G

GENERAL

320. Fluid flow with exchange of mass, energy and momentum. J. LITWINSZYN, *Arch. Mech. Stosowanej*, 1957, **2**, (6), 669—694. Modifications of the equations of fluid dynamics allowing for the exchange of mass, momentum and energy are developed. The treatment has applications in practice, e.g. pipe networks into which mass is pumped. [In English] P.F.

321. Extremum theorems in the theory of plasticity of non-homogeneous and anistropic bodies. W. OLSZAK and P. PERZYNA, *Arch. Mech. Stosowanej*, 1957, **9**, (6), 695—712. [In English] P.F.

322. Application of certain stochastic processes to the computation of mean geostatic pressures. A. GRUZEWSKI, *Arch. Mech. Stosowanej*, 1958, **10**, (1), 115—123. (In English] P.F.

323. The role of water in extrusion and its modification by a surface-active chemical. G. C. ROBINSON and J. J. KEILEN, *Bull. Amer. Ceram. Soc.*, 1957, **36**, 422—430. Ceramic Engng Dept., Clemson College, Clemson, S.C., U.S.A. The following properties are modified by water content and addition of surface-active chemicals : extrusion speed, plastic strength, dry strength, fired strength, fired absorption and total shrinkage. B.N.

324. Effects of storage temperature on firming of cake crumb. J. W. PENCE and N. N. STANDRIDGE. *Cereal Chem.*, 1958, **35**, 57—65. Barley & Malt Laboratory, U.S. Department of Agriculture, Madison, Wisconsin, U.S.A. Firming of crumb of yellow layer, chocolate layer, angel food, and pound cakes, measured as force per fixed deformation on standard sections, became progressively more rapid at storage temperatures of 0°, 10°, 20°, 34°, and 70° F (−18°, −12°, −7°, 1° and 21° C.) The firming rates, in general, were rather small and seldom significantly different between adjacent temperatures because of both the slow rates of change in firmness and a relatively large variation in firmness of the starting material. The firming rates of cakes were so small as to suggest that firmness changes might be of lesser concern in frozen or refrigerated storage of cakes than possible changes in flavour, moisture, or other aspects of texture. Freezing points of the cakes used fell between 3° and 8° F (−16° and 13° C). The retarding effect of lower temperatures on rate of firming of cake crumb explains in part their pronounced tolerance to variation in freezing and refrigeration conditions in commercial cake-freezing practice. Author

325. The mesomorphic state : liquid crystals. G. H. BROWN and W. G. SHAW, *Chem. Rev.*, 1957, **57**, 1049—1157. Dept. of Chemistry, Univ. of Cincinnati, Cincinnati, Ohio, U.S.A. This review article contains a section (pp. 1095—1100) on the viscosity of the mesomorphic state. Reference is made to the similarity between the viscosity characteristics of mesomorphs to those of emulsions. The influence of magnetic and electric fields on viscosity is also discussed. W.G.C.

326. Condensed sulphite-alcohol residue as a new reagent for the improvement of drilling muds. Z. P. BUKS, *Neft. Khoz.* (*Oil Industry, Moscow*), December 1957, 26—29. (From *D.S.I.R. Translated Contents List.*) [Russian] J.F.H.

327. Conference on lubrication and wear. ANON, *Sci. Lubric.*, Special Issue, December 1957. Summaries, some of them long and detailed, of 104 papers presented at a conference held in October 1957 and arranged by the Institution of Mechanical Engineers. Also includes condensed verbatim records of selected sections of the discussions that followed the papers. Full official proceedings of the conference will be published by the Institution in Autumn 1958. Some of the papers are concerned with the rheology of non-Newtonian lubricants. J.F.H.

328. The need for fundamental research in strength of materials. M. V. ZAUSTIN, *A.S.T.M Bull.*, 1957, **226**, 52. Jet propulsion Laboratory,

California Institute of Technology, Pasadena, Calif., U.S.A. Ordinary physical test data are no longer sufficient for satisfactory design with engineering materials. Factors to be taken into account are the effects of non-linearity and arisotropy, non-uniform stress statistical variations of strength within a sample, fatigue, effect of temperature changes, etc.
E.B.A.

329. The mathematical treatment of mineral oil recovery by water displacement. D. MARSAL, *Erdöl u. Kohle*, 1957, **10**, 825—826. Gewerkschaft Elwerath, Hanover. Oil can be won from the earth by displacing it from the porous strata with water. Mathematical analysis of the problem have so far been concerned only with simple linear cases. This note (a fuller report is in preparation) describes how a more complete analysis has been achieved using a computer. [German] T.F.H.

330. Intermolecular forces in quasi-spherical molecules. J. C. MCCOUBREY and N. M. SINGH, *Trans. Farad. Soc.*, 1957, **53**, 877, 883. Dept. of Chemical Engineering, Imperial College, London, S.W.7. Measurements are reported on the viscosity of the vapours of CF_4, SF_6, SiF_4, $C(CH_3)_4$, BF_3, and $(CH_2)_3$, in the temperature range 20—180° C. Experimental results have been fitted to several models of intermolecular potential and the parameters of fit are given. The results are consistent with the suggestion that the net attractions and repulsions between molecular centres of these quasi-spherical molecules are steeper than those between the centres of truly spherical molecules. Author

VOL.
1
1958

Analyt. Chem.
Ann. N.Y. Acad. Sci.
Appl. Sci. Res., Gravenhage.
Arch. Mech. Stosowanej.
A.S.T.M. Bull.
Aust. J. Appl. Sci.
Aust. J. Phys.

Bitumen, Teere, Asphalte u. Peche
Brit. Chem. Engng.
Brit. J. Appl. Phys.
Brit. Plast.
Brot. u. Gebäck.
Bull. Acad. Sci. U.R.S.S.
Bull. Amer. Ceram. Soc.

Canad. J. Chem.
Canad. J. Phys.
Cereal Chem.
Chem. Rev.
Chim. et Industr.
Clays and Clay Min.
Clay Min. Bull.
Coll. Trav. Chim. Tchécosl.
C.R. Acad. Sci.

Dairy Ind.
Diss. Abs.
Dokl. Akad. Nauk SSSR
DSIR Contents List

Engineer, Lond.
Engineering, Lond.
Erdöl u. Kohle

Faserforschung
Fluid Handling
Food Tech.

Glass Ind.
Glastech. Ber.
Glycerine News

Helv. Chim. Acta.
Helv. Phys. Acta.

Ind. Eng. Chem.
Indust. Chem.
Instrum. Pract.

J. Amer. Ceram. Soc.
J. Amer. Chem. Soc.
J. Amer. Leath. Chem. Ass.
J. Amer. Oil Chem. Soc.
J. Appl. Mech.
J. Appl. Phys.
J. Ceram. Ass. Japan
J. Chem. Educ.
J. Chem. Phys.
J. Chem. Soc.
J. Chim. Phys.
J. Colloid Sci.
J. Dairy Res.
J. Dairy Sci.
J. Fluid Mech.
J. Franklin Inst.
J. Imp. Coll. Chem. Engng. Soc.
J. Inst. Fuel
J. Inst. Met.
J. Inst. Petrol
J. Mech. Phys. Solids
J. Oil Col. Chem. Ass.
J. Phys. Chem.
J. Polym. Sci.
J. Rat. Mech. Anal.
J. Res. Nat. Bur. Stand.
J. Sci. Fd. Agric.
J. Sci. Industr. Res.
J. Sci. Instrum.
J. Soc. Dy. Col.
J. Soc. Glass Tech.
J. Soc. Leath. Tr. Chem.
J. Soil Sci.
J. Text. Inst.

Kolloidnyĭ Zh.
Kolloidzschr.
Kunststoffe

Lab. Practice
Lubric. Engng.

Mod. Plast.

Nature, Lond.
Neftyanoe Khoz.
NLGI Spokesman
Nuovo Cim.

Oil Ind., Moscow

Paint Manuf.
Paint Tech.
Petrol Engr.
Petrol Process.
Petrol Refin.
Petroleum, Lond.
Phil. Mag.
Phil. Trans.
Phys. Rev.
Plastics, Lond.
Plastics Tech.
Proc. Camb. Phil. Soc.
Proc. Phys. Soc. Lond.
Proc. Roy. Soc.
Proc. Soil Sci. Soc. Amer.
Process Control

Quart. Appl. Math.

Research, Lond.
Rev. de l'Inst. franç. du pétrole
Rev. Mod. Phys.

VOL.
1
1958

VOL.
1
1958

Section A

THEORETICAL

331. The rheological equation of state. H. GIESEKUS, *Rheologica Acta*, 1958, No. 1, 2—20. Farbenfabriken Bayer A.G., Leverkusen, Germany. A brief review is given of the general form of relation between stress, strain, and time derivatives of strain, appropriate to an isotropic visco-elastic continuum subjected to finite strains. Expressions for normal and tangential stress components are derived for the case of steady shear flow, and the extent to which these can be determined using cone-and-plate, parallel plate, and concentric cylinder viscometers is considered. A general formalism for calculating the stress in a flowing solution of independent rigid or deformable particles is outlined; applied to the case of a suspension of identical elastic dumb-bells, non-zero differences for normal stress components in steady shear flow are obtained, and stress relaxation is found to involve one period when the dumb-bells are easily deformable and five periods otherwise. [German] A.S.L.

332. Minimum principles of piecewise linear isotropic plasticity. P. G. HODGE, *J. Rat. Mech. Anal.*, 1956, **5**, 917—938. A theory of plasticity is considered in which the yield function is a piecewise linear function of the stresses, the flow law is based on the plastic potential, and the strain-hardening is isotropic and linear. First, the flow law at a "corner" of the yield function is investigated in detail. Next it is shown that the flow law at all points can be piecewise integrated to obtain some of the advantages of a deformation theory. Finally, two classical minimum principles of elasticity are extended to include certain cases of linear piecewise plasticity. Author

333. Elastic-plastic bending of a built-in circular plate under a uniformly distributed load. B. TEKINALP, *J. Sci. Industr. Res.*, 1957, **5**, 135—142. The paper contains an analysis of the bending moments and deflections of a uniformly loaded and built-in circular plate that is made of an incompressible elastic-plastic material obeying Tresca's yield condition and the associated flow rule. The analysis is simplified by assuming that any plate element is either entirely elastic or entirely plastic. This assumption is practically fulfilled for a sandwich plate; for a solid plate it represents a first approximation to the actual diagram of bending moment vs. curvature. Author

334. Creep relaxation for combined stresses. J. E. GRIFFITH and J. MARIN, *J. Mech. Phys. Solids*, 1956, **4**, 283—293.

335. A note on the deformable region in a rigid plastic body. G. F. W. BISHOP, A. P. GREEN and R. HILL, *J. Mech. Phys. Solids*, 1956, **4**, 256—258.

336. The plastic yielding of shallow notched bars due to bending. A. P. GREEN, *J. Mech. Phys. Solids*, 1956, **4**, 259—268.

337. On the problem of uniqueness in the theory of a rigid-plastic solid. R. HILL, *J. Mech. Phys. Solids*, 1956, **4**, 247—255.

338. The propagation of infinitesimal plane waves in elastic-plastic materials. J. W. CRAGGS, *J. Sci. Industr. Res.*, 1957, **5**, 115—124. The propagation of small discontinuities of stress in a plastic-elastic material is examined. It is shown that plane waves of two types may exist, each involving both dilatation and shear strain, and an equation for the velocities of such waves is given. Possible interactions between plastic (loading) and elastic (unloading) waves are discussed and the treatment of such interactions is illustrated by examples. Author

339. Elasticity and plasticity. F. A. VENING MEINESZ, *Appl. Sci. Res.* A, 1957, **6**, 305–325. Dealing with stress-strain relations, the writer separates the states of stress and strain into two parts, the compression by hydrostatic pressure and the change of shape by the deviatoric part of the stress ; each part has its own behaviour and modulus. He develops a graphical representation of the state of stress which gives a simple way of comparing the different states of stress corresponding to the yield limit. Author

VOL. 1 1958

340. On uniqueness and stability in the theory of finite elastic strain. R. HILL, *J. Mech. Phys. Solids*, 1957, **5**, 229—241.

341. A general theory of piecewise linear plasticity based on maximum shear. P. G. HODGE, *J. Mech. Phys. Solids*, 1957, **5**, 242—260. A theory of plasticity is developed for a material that is initially isotropic and satisfies the maximum shear-stress in initial-yield condition. It is shown that the most general piecewise linear theory depends upon 5 material constants.

342. On the type of the equations in the theory of plasticity. YU. M. LIBERMAN, *C. R. Acad. Sci. USSR*, 1957, **116**, 32—34. [Russian] M.F.C.

343. Use of an analogue to resolve Stokes's Paradox. R. V. SOUTHWELL, *Nature, Lond.*, 1958, **181**, 1257—1258, Trumpington, Cambridge. The stream function defining slow, steady laminar motion of an incompressible and viscous fluid satisfies an equation identical in form with that which governs the displacement of a bent elastic plate. By use of this analogue, it is shown that Stokes's postulates, for the solution of the problem of slow flow past a cylinder, are inadmissible. W.G.C.

344. On the most general form of the compatibility equations and the conditions of integrability of strain rate and strain. E. H. BROWN, *J. Res. Nat. Bur. Stand.*, 1957, **59**, 421—426. The most general forms of the equations of compatibility are derived by a very simple analysis in terms of the material strain rate tensor and the rate of change of the Riemann–Christoffel curvature tensor during the deformations. It is shown that recent statements on the significance of the compatibility equations, essentially that their satisfaction is equivalent to the condition that the space be locally Euclidean, are misinterpretations based on restricted forms of the equations. In addition, a new form of the conditions of integrability of strain is derived in terms of the rate of change of the curvature tensor. M.F.C.

LIST OF JOURNALS COVERED FOR RHEOLOGY ABSTRACTS

Rev. Sci. Instrum.
Rubb. Chem. Technol.

Sci. Ladoiz.
Silicates Industr.
Soil Sci.
Sov. Phys. JETP
S.P.E.J.
Svensk Papperstidning

Teppi

Text. Res. J.
Trans. Brit. Ceram. Soc.
Trans. Faraday Soc.
Trans. Plast. Inst., Lond.
Trans. Soc. Rheol.

Verres et Refr.

Wire Ind.
Wire Prodn.
Wire and Wire Prodn.

338. The propagation of infinitesimal plane waves in elastic-plastic materials. J. W. CRAGGS, *J. Sci. Industr. Res.*, 1957, **5**, 115—124. The propagation of small discontinuities of stress in a plastic-elastic material is examined. It is shown that plane waves of two types may exist, each involving both dilatation and shear strain, and an equation for the velocities of such waves is given. Possible interactions between plastic (loading) and elastic (unloading) waves are discussed and the treatment of such interactions is illustrated by examples. Author

339. Elasticity and plasticity. F. A. VENING MEINESZ, *Appl. Sci. Res.* A, 1957, **6**, 305–325. Dealing with stress-strain relations, the writer separates the states of stress and strain into two parts, the compression by hydrostatic pressure and the change of shape by the deviatoric part of the stress ; each part has its own behaviour and modulus. He develops a graphical representation of the state of stress which gives a simple way of comparing the different states of stress corresponding to the yield limit. Author

VOL. 1 1958

340. On uniqueness and stability in the theory of finite elastic strain. R. HILL, *J. Mech. Phys. Solids*, 1957, **5**, 229—241.

341. A general theory of piecewise linear plasticity based on maximum shear. P. G. HODGE, *J. Mech. Phys. Solids*, 1957, **5**, 242—260. A theory of plasticity is developed for a material that is initially isotropic and satisfies the maximum shear-stress in initial-yield condition. It is shown that the most general piecewise linear theory depends upon 5 material constants.

342. On the type of the equations in the theory of plasticity. YU. M. LIBERMAN, *C. R. Acad. Sci. USSR*, 1957, **116**, 32—34. [Russian] M.F.C.

343. Use of an analogue to resolve Stokes's Paradox. R. V. SOUTHWELL, *Nature, Lond.*, 1958, **181**, 1257—1258, Trumpington, Cambridge. The stream function defining slow, steady laminar motion of an incompressible and viscous fluid satisfies an equation identical in form with that which governs the displacement of a bent elastic plate. By use of this analogue, it is shown that Stokes's postulates, for the solution of the problem of slow flow past a cylinder, are inadmissible. W.G.C.

344. On the most general form of the compatibility equations and the conditions of integrability of strain rate and strain. E. H. BROWN, *J. Res. Nat. Bur. Stand.*, 1957, **59**, 421—426. The most general forms of the equations of compatibility are derived by a very simple analysis in terms of the material strain rate tensor and the rate of change of the Riemann–Christoffel curvature tensor during the deformations. It is shown that recent statements on the significance of the compatibility equations, essentially that their satisfaction is equivalent to the condition that the space be locally Euclidean, are misinterpretations based on restricted forms of the equations. In addition, a new form of the conditions of integrability of strain is derived in terms of the rate of change of the curvature tensor. M.F.C.

345. On Voterra's dislocations in a semi-infinite elastic medium. J. A. STEKETEE, *Canad. J. Phys.*, 1958, **36**, 192—205. A Green's function method is developed to deal with the problem in such a way that the boundary surface of the medium remains free from stresses. Some results may be of geophysical interest. M.F.C.

346. The theory of plasticity with the Bauschinger effect taken into account. YU. I. KADASHEVICH and V. V. NOVOZHILOV, *C. R. Acad. Sci. USSR*, 1957, **117**, 586—588. [Russian] M.F.C.

347. The causes responsible for the divergence between the kinetic theory of high elasticity and experience. L. S. PRISS, *C. R. Acad. Sci. USSR*, 1957, **116**, 225—228. [Russian] M.F.C.

348. Stress relaxation and creep of linear viscoelastic substances under varying temperature. I. L. HOPKINS, *J. Polym. Sci.*, 1958, **28**, 633 (letter). Bell Telephone Labs. Inc., Murray Hill, New Jersey, U.S.A. The stress relaxation and creep of a linear viscoelastic body subjected to temperature variations is examined theoretically in the light of previous results for these materials at various constant temperatures. D.W.S.

349. Non-Newtonian effects in steady motion of some idealized elastico-viscous liquids. J. G. OLDROYD, *Proc. Roy. Soc.* A, 1958, **245**, 278—297. Department of Applied Mathematics, University College of Swansea. Normal-stress effects and the variation of apparent viscosity with rate of shear in simple types of steady flow of certain idealized elastic-viscous liquids are discussed. The liquids are those whose behaviour at sufficiently small variable shear stresses can be characterized by three constants (a coefficient of viscosity, a relaxation time and a retardation time) and whose invariant differential equations of state for general motion (involving eight independent physical constants) are linear in the stresses and include terms of no higher degree than the second in the stresses and velocity gradients together. The normal stresses which, in addition to shear stresses, are present in such a liquid in a state of simple shearing flow, or in flow in a circular pipe, or between rotating cylinders, are investigated; and the conditions under which the Weissenberg climbing effect will occur, in positive or negative sense, are examined. In many liquids of this class, steady rectilinear flow under a uniform pressure gradient is not always possible in a straight pipe of arbitrary section, nor in steady flow in horizontal circles in a region bounded by arbitrary surfaces of revolution in relative rotation about common vertical axis. The behaviour of these idealized liquids when sheared in a narrow gap between a rotating wide-angled cone and flat plate is compared with the observations made on some real elastico-viscous liquids. Author

350. The behaviour of a vibrating visco-elastic cylinder. N. B. TERRY, *Proc. Phys. Soc. Lond.*, 1958, **71**, 973—978, Mining Research Establishment, N.C.B., Isleworth, Middlesex. The general differential equation of wave-motion for a Burgers body is used to express the attenuation and retardation time of a visco-elastic material in terms of the mechanical quality factor of a cyclinder of the material set into forced vibration. It is assumed that the vibrations are induced by the action of a sinusoidal stress at one end of the cylinder. Author

351. Flow of a viscous liquid on a rotating disk. A. G. EMSLIE, F. T. BONNER and L. G. PECK, *J. Appl. Phys.*, 1958, **29**, 858—862. Equations describing the flow of a Newtonian liquid on a rotating disk have been solved so that characteristic curves and surface contours at successive times for any assumed initial fluid distribution may be constructed. It is shown that centrifugation of a fluid layer that is initially uniform does not disturb the uniformity as the height of the layer is reduced. It is also shown that initially irregular fluid distributions tend towards uniformity under centrifugation, and means of computing times required to produce uniform layers of given thickness at given angular velocity and fluid viscosity are demonstrated. Contour surfaces for a number of exemplary initial distributions have been constructed. Edge effects on rotating planes with rising rims, and fluid flow on rotating nonplanar surfaces, are considered.
Authors

VOL.
1
1958

352. Nature of the glass transition and the glassy state. J. H. GIBBS and E. A. DIMARZIO, *J. Chem. Phys.*, 1958, **28**, 373—383, Research and Development Division, American Viscose Corporation, Marcus Hook, Penn., U.S.A. Statistical mechanics is used to calculate the thermodynamic properties of an amorphous polymer phase, allowing for chain stiffners. A transition qualitatively similar to a " glass " transition is predicted, and on the basis of a tentative identification of the two, the dependence of glass temperature upon molecular weight and solvent content, and dependence of volume upon temperature is predicted. Excellent agreement is found with experimental results. E.B.A.

353. Uniqueness of the solution of approximate boundary problems in the dynamics of an incompressible fluid of variable viscosity. S. A. REGIRER, *C. R. Acad. Sci. USSR*, 1957, **117**, 384—386. [Russian] M.F.C.

354. Bulk viscosity and shear viscosity in fluids according to the theory of irreversible processes. K. F. HERZFELD, *J. Chem. Phys.*, 1958, **28**, 595—600. Catholic University of America, Washington, D.C., U.S.A. M. Green has connected the shear and bulk viscosities with the fluctuations of the virial. It is shown here that the virial theorem is correct at every moment, including the fluctuations, if the integral of the pressure over the volume is taken. For monatomic fluids the bulk viscosity is calculated after introducing an unknown correlation length ; for fluids with internal degrees of freedom or with two state structure, the usual equations follow very easily. For the shear viscosity one finds a formula similar to that of Eyring by making some assumptions about correlations.
Author

355. Eyring's model of flow applied to thixotropic equilibrium. SVEN-ERIC DAHLGREN. *J. Colloid. Sci.*, 1958, **13**, 151. A.B. Förenade Superfosfatfabriker, Landskrona, Sweden. The concept of thixotropy is discussed and a definition presented. It is shown that Eyring's model of flow can describe the equilibrium curve of thixotropic substances with two or more coexistent place-exchange mechanisms. A numerical example of the determination of the equlibrium equation of a thixotropic substance is given. Author

356. On the theory of non-stationary ruptures in relaxing media. E. V. STUPOCHENKO and I. P. STAKHANOV, *C. R. Acad. Sci. USSR*, 1957, **117**, 65—67. [Russian] M.F.C.

357. A survey of the mathematics available for describing fracture. A. E. SCHEIDEGGER, *Canad. J. Phys.*, 1958, **36**, 300—308. An attempt is made to extend the mathematical finite strain theory of general rheological bodies to the inclusion of discontinuous displacements. A particularly simple type of discontinuity, i.e. dislocations, has been chosen for special investigation. M.F.C.

Section B

INSTRUMENTS AND TECHNIQUES

358. An immersion viscometer. F. D. PENNY and G. C. ACKROYD, *Petroleum Lond.*, 1958, **21**, 196. D.S.I.R. Fuel Research Station. Details of the design, the method of calibration, and some experimental results are given for a new type of immersion viscometer. The viscometer was designed to measure the viscosity of oil in storage tanks at depths of up to 30 ft. A.D.B.

359. A compensated moving cylinder viscometer. G. M. SREEKANTATH and C. A. VERGHESE, *J. Sci. Instrum.*, 1958, **35**, 160—161. University College, Trivandrum, Kerala State, India. A new viscometer has been designed, in which the only measurement to be made is the time taken by the cylinder to move a definite distance, without the necessity of either observing the movement of the cylinder or measuring the densities of the cylinder and of the liquid. The instrument consists of two exactly similar light cylinders moving in similar vertical tubes of slightly large diameters. The instrument is capable of high accuracy. Author

360. A high shear viscometer. ANON, *Paint Manuf.*, 1958, **28**, 182. A new rotating cylindrical viscometer is described with 100 micron gap. The bob is clamped to the rotating shaft of a Stormer viscometer. Two wells are included in the walls of the cup to provide discontinuity approximating to that between paint brush bristles. Good correlation for paints between instrumental results (12,000—35,000 sec^{-1} range) and brushability by experienced painters is claimed. R.J.C.

361. Measurements of the viscosity of molten cast iron. A. KÖNIGER and M. THIELE, *Rheologica Acta*, 1958, No. 1, 32—38. Foundry Research Institute, Technischen Universität, Berlin-Charlottenburg, Germany. A rotational viscometer with ceramic members is described for use at high temperatures. Owing to the shape of the rotor, the viscometer is not an absolute instrument and is calibrated at room temperature using standard oils. The torque on the rotor is determined by its influence on the current supplied to the motor. Viscosity data in the temperature range 1200°C to 1400°C are given for four cast iron samples of different phosphorus content. [German] A.S.L.

362. Experimental investigation of a rotation viscometer with coaxial cylinders. M. POPOV, *Rheologica Acta*, 1958, No. 1, 70—77. Technical Highschool, Sofia, Bulgaria. The relation between torque and angular velocity ceases to be linear at a Reynolds number of about 6 when the cylinders have flat ends and 95 when the cylinders have hemispherical

ends (ratio of cylinder radii=0·832) ; similar data in the latter case are given for different ratios of cylinder radii. The departure from linearity is attributed to the onset of the turbulence observed in the gaps between the cylinder ends for Reynolds' numbers above 3. The outer cylinder is rotated ; the liquid used is Newtonian. Errors introduced by parallel displacement of the cylinders axes are measured. For comparison, linearity data obtained with a Hatschek (guard-ring concentric cylinder) viscometer and with a concentric sphere viscometer are given. [German]
A.S.L.

363. A simple melt-viscometer for very high viscosities. P. A. SMALL, *J. Polym. Sci.*, 1958, **28**, 223 (letter). I.C.I., Welwyn Garden City, Herts, England. A simple melt-viscometer has been devised which allows measurement of viscosities from 10^4 to 10^9 poises to be measured on 0·1 g of material. The viscometer consists of a metal plunger which is forced into the melt contained in a glass tube. The motion of the plunger under known load is followed. The theory of the method is given for a non-elastic Newtonian fluid. D.W.S.

VOL. 1 1958

364. Effect of the viscosity and temperature of the liquid on the inaccuracy of readings of volumetric meters. M. M. KARABEINIK, *Neftyanoe Khoz.* February, 1958, p. 54. (From *D.S.I.R. List* No. 110, May 1958.) [Russian] J.F.H.

365. The determination of the dynamic Young's modulus and dynamic shear modulus in the frequency range 10^{-3} to 10^{-1} cycles per second J. KOPPELMANN, *Rheologica Acta*, 1958, No. 1, 20—28. Physikalisch-Technischen Bundesanstalt, Braunschweig, Germany. The apparatus measures the amplitude and phase of strain for an applied oscillatory stress for samples of solid polymers subjected to bending, torsion, simple shear, and simple extension. Values of dynamic Young's and shear moduli and of loss factor are given for samples of polyvinylchloride plasticized with different amounts of dioctylphthalate and for a plasticized sample of polymethylmethacrylate at frequencies in the range 10^{-3} to 10^3 cycles per second. Static measurements can also be made ; creep and recovery data for torsional deformations are given for one of the PVC samples. Data are obtained at room temperature, but provision exists for changing the temperature. [German] A.S.L.

366. Constant-stress creep apparatus. R. C. BOETTNER and W. D. ROBERTSON, *Rev. Sci. Instrum.*, 1956, **27**, 1039—1040. A simple creep apparatus for approximating a constant stress in tensile specimens of large cross-sections, where large applied loads are required, is described. The apparatus consists of a lever with a large built-in mechanical advantage together with means for removal of incremental weights from the applied road. Author

367. A procedure for testing the low temperature behaviour of bituminous materials. K. KRENKLER, *Bitumen, Teere, Asphalte u Peche*, 1958, **9**, 146—151. Stuttgart. Results are presented to show that the Fraas breaking point (the temperature below which a bitumen is brittle) can be predicted from values of penetration measured at higher temperatures. [German] J.F.H.

368. An experimental investigation of the deformed zone associated with indentation hardness impressions. L. E. SAMUELS and T. O. MULHEARN, *J. Sci. Industr. Res.*, 1957, **5**, 125—134.

369. A method of measuring heating effects in deformation processes. F. H. MÜLLER and AD. ENGELTER, *Rheologica Acta*, 1958, No. 1, 39—53. High Polymer Laboratory, Philipps University, Marburg/Lahn, Germany. An accurate calorimeter is developed in which the heat evolved during extension of a test piece causes in the surrounding gas atmosphere an increase of pressure which is used as the basis of a null method. The accuracy of the method and the effect of size of the test piece are considered. Heating rates of 5×10^{-4} cal/sec and total heat changes of the order 10^{-3} to 10^{-1} cals can be measured. Using different gases, response times of 0·6 sec to 5 sec are obtained. The apparatus is used to record the rate of evolution of heat as a function of time during the extension of steel and Invar wires and during the cold-drawing of a polyamide sample. [German] A.S.L.

370. Birefringence determination in objects of irregular cross-sectional shape and constant weight per unit length. S. C. SIMMENS, *Nature, Lond.*, 1958, **181**, 1260—1261. British Cotton Industry R.A., Shirley Institute, Didsbury, Manchester 20. In elongated objects of irregular cross-sectional shape (e.g. silk and viscose rayon filaments and fibres, or filaments containing cavities), the thickness of the object seen in a polarising microscope cannot readily be determined. By employing a modified photographic technique an appreciable sharpening of two-beam fringes, contouring the filaments, can be obtained. Results for viscose rayon filaments are in good agreement with those obtained by the Becke line method. W.G.C.

371. Apparatus for the observation of infrared streaming dichroism of polymer solutions. G. R. BIRD, M. PARRISH, Jr., and E. R. BLOUT, *Rev. Sci. Instrum.*, 1958, **29**, 4, 305—309. Research Laboratory, Polaraid Corp., Cambridge 39, Massachusetts. The design, construction, and operation of apparatus for the quantitative observation of infrared streaming dichroism of solutions of macromolecules are described in detail. The apparatus consists of a modified standard infrared liquid cell through which the solution is pumped by means of a pair of hypodermic syringes which are driven by a pair of cams that provide a constant rate of displacement. The resulting flow is constant except for a renewal in direction at the end of each stroke and the maximum value of the gradient in the cell may be calculated. The total volume of the pump and cell is only 2·2 cc. Several types of material have been measured and a typical result is shown. H.J.R.

372. A double D.C. bridge circuit for precision measurements with load cells. T. S. PARRAMORE, *J. Sci. Instrum.* 1958, **35**, 162—163. Ministry of Supply, Military Engineering Experimental Establishment, Christchurch. By arranging the strain gauges on a load cell as a closed bridge which is wired in parallel with a similar reference bridge in the measuring instrument, a very sensitive and accurate manually balanced null deflection method of measuring the output of a load cell can be achieved at low cost. The prototype bridge has a discrimination of one part in 10,000. Author

373. The ultracentrifuge as an instrument for testing adhesion. R. L. PATRICK, W. A. VAUGHAN and C. M. DOEDE, *J. Polym. Sci.*, 1958, **28**, 11. Quantum Inc., Wallingford, Connecticut, U.S.A. A technique was developed which allows the determination of essentially pure tensile strengths of single interface adhesive samples. Utilising a suitably modified ultracentrifuge, model adhesive systems were ruptured in an attempt to obtain relative strengths of adhesive bonds in the interface. Author

374. A macrotome for preparing smooth and flat surfaces in butter and materials of similar consistency. J. W. CLAASSENS, *Lab. Practice*, 1957, **6**, 653—657. M.F.C.

375. The selection and location of flow measurement devices. W. F. COXON, *Industr. Chemist*, 1957, **33**, 441—445. Discusses the principles of flow measurement, the characteristics of some measuring devices, and their location in pipe systems. M.F.C.

VOL.
1
1958

376. Some aids to the design of dies for Plastics Extrusion Part 2. D. J. WEEKS, *Brit. Plast.*, 1958, 201—205. I.C.I. Ltd., Plastics Division, Welwyn Garden City, England. Pressure prediction is a preliminary to calculating mechanical stresses and distortions in a die and it is also the starting point for extruder screw design. Flow distribution expressions have been derived for certain sheet and film dies ; these give the required internal dimensions to obtain a specific thickness tolerance across the product. Also described are certain flow simulation techniques for discovering and and eliminating dead spaces. Stressing distortion, and heating of dies are not covered. Author

Section C

METALS AND OTHER SOLIDS

377. Dynamic and static elasticities of solids. J. F. W. BELL, *Nature, Lond.*, 1958, **181**, 1330. Dept. of Physics, Royal Naval College, Greenwich, London, S.E.10. Pulses are launched and received by coils on a magnetostrictive tube, and these are used to measure the longitudinal, v_L, and the torsional, v_T, velocities of sound in thin rods. Using the expression

$$\frac{\gamma E}{n} = \frac{v_L^2}{v_T^2} = 2\gamma(1+\sigma)$$

(where γ = ratio of specific heats, E and n are Young's and rigidity moduli), Poisson's ratio σ was determined for several specimens. The good agreement between observed and textbook values of σ is stated to show the value and accuracy of the expression for the analysis of dynamic measurements. W.G.C.

378. An interpretation of the general equation for the creep of metals. I. A. ODING, *C. R. Acad. Sci. USSR*, 1957, **116**, 66—70. [Russian] M.F.C.

379. Adsorption plasticisation of the surface layer by lubricants in pressure working of metals. S. J. VEILER, V. I. LICHTMAN and P. REHBINDER, *C. R. Acad. Sci. USSR*, 1957, **116**, 415—418. [Russian] M.F.C.

380. The effect of thin mercury coatings on the strength of metallic single crystals. V. N. ROZHANSKY, N. V. PERTZOV, E. D. SHCHUKIN and P. REHBINDER, *C. R. Acad. Sci. USSR*, 1957, **116**, 769—771. M.F.C.

381. Some effects of low temperatures and notch depth on the mechanical behaviour of an annealed, commercially pure titanium. G. W. GEIL and N. L. CARWILE, *J. Res. Nat. Bur. Stand.*, 1957, **59**, 215—226. Tensile tests were made at temperatures between −196 and +150°C, and impact tests from −196°C to +300°C. True stress–strain relations were determined for titanium in tension. A study was made of the effects of temperature, stress system and interstitial content on the mechanism of deformation and work-hardening characteristics. M.F.C.

382. The effect of heat treatment on low temperature internal friction maxima. T. S. HUTCHISON and G. J. HUTTON, *Canad. J. Phys.*, 1958, **36**, 82—87. Measurements of the attenuation of sound at a frequency of 5 mc/s have been made over the temperature-range 100° to 200° k. on polycrystalline high purity aluminium subjected to various thermal and mechanical treatments. M.F.C.

383. Impact properties of slack-quenched alloy steels. M. R. MEYERSON and S. J. ROSENBERG, *J. Res. Nat. Bur. Stand.*, 1957, **59**, 273—288. Specimens were prepared with uniform and accurately controlled hardnesses and microstructures at any location in the cross-section. The effects of boron and carbon content, tempering and hardening, were studied. M.F.C.

384. The change of length during transformation of iron under stress. M. DE JONG and G. W. RATHENAU, *Nature, Lond.*, 1958, **181**, 1396—1397. Natuurkundig Laboratorium, Universiteit van Amsterdam, Holland. Specimens of pure iron were examined when heated through the transformation temperature at 910°C. The change of length has given linear plots for the α–γ and γ–α transformations and for the complete α–γ–α cycle as a function of stress. Linearity is not obtained with coarse-grained irons. A brief explanation of these phenomena is considered. W.G.C.

385. Apparent compressive strength of brick. N. W. KELCH and F. E. EMME, *A.S.T.M. Bull.*, 1958, No. 230, 38—41. Associated Brick Manuf. of S. California. The effect of capping specimens of clay brick or structural clay tile specimens with sulphur or gypsum plaster upon the compressive strength was studied. E.B.A.

386. Contribution to the rheological study of asphalt concretes. J. J. ORTEGA, Laboratorio Central de Ensayo de Materiales de Construccion, Publication No. 86, 1955, Madrid. The research aimed at setting up an accurate experimental method for studying the rheology of asphalt concrete, to improve upon the standard empirical methods used hitherto to estimate the physico-chemical structure. A coaxial cylinder viscometer was used. A modified Marcusson's method was used for extraction of the constituents. D.P.O.

387. Discussion of a paper on effect of length to diameter ratio on compressive strength of concrete. SEVERAL AUTHORS, *A.S.T.M. Bull.*, 1958, No. 229, 73—76. Discussion of a paper by J. W. MURDOCK and C. E. KESLER (*A.S.T.M. Bull.*, 1957, No. 221, 68). Contributors give further data on effect of length to diameter ratio on compressive strength of concrete columns. E.B.A.

388. Rheological investigations of the setting of gypsum. V. B. RATINOV, T. I. ROZENBERG, G. G. BOGAUTDINOVA and G. D. STALIKOVA, *Colloid J. (USSR)*, 1956, **18**, 227—230. Two periods are distinguished in the setting of gypsum. In the first it behaves as an elasto-plastic body, in the second as a brittle soild. D.P.O.

389. On a new theory of mountain building. A. E. SCHEIDEGGER, *Canad. J. Phys.*, 1957, **35**, 1380—1386. An investigation of the forces which could have caused continental drift, if such has occurred, leading to a new theory of mountain building. This is based on the assumption of a random drag force with a correlation time of 150 million years. M.F.C.

390. Influence of inerts on the dilatometric properties of coal. S. SARKER, N. N. DAS GUPTA and A. LAHIRI, *J. Sci. Industr. Res.*, 1958, **17B**, 127—131. Central Fuel Research Institute, Jealgora, Bihar, India. The influence of various inert materials (e.g., kaolin, sand, electrode carbon, and alumina) on the dilatometric and plastic properties of a coal has been studied using the Sheffield Coking Test apparatus and the Gieseler Plastometer. With increase in inerts content, the expansion of coal initially increases, passes through a zone of equilibrium and finally decreases linearly. A hypothesis is proposed for explaining the mechanism of swelling (cf. Rheology Abstracts, 1958, **1**, No. 233). Author

391. Dislocations in mechanical calcite twins. G. B. RAIS, *C. R. Acad. Sci. USSR*, 1957, **117**, 419—422. [Russian] M.F.C.

392. Polymer-type elasticity in non-polymer crystals. J. E. GORDON, A. T. K. SEVILLE and D. M. MARSH, *Nature, Lond.*, 1958, **181**, 1678. Tube Investments Research Laboratories, Hinxton Hall, Cambridge. Young's modulus, E, for α-hydroquinone has been measured along the c-axis of the crystal. The value obtained for E is very low for a crystalline material, and is, in fact, similar to that of many resins. An explanation for this low modulus is suggested. W.G.C.

393. Contractions of activated carbon on adsorption of gases and vapors at low initial pressures. M. L. LAKHANPAL and E. A. FLOOD, *Canad. J. Chem.*, 1957, **35**, 887—899. The shrinkage of materials when they adsorb *small* quantities of vapors has been studied experimentally and theoretically. It is suggested that shrinkage is due to "bridging" of sites by adsorbate molecules. M.F.C.

394. Elastic properties of glass. E. K. KELLER and E. I. KOZLOVSKAIA, *C. R. Acad. Sci. USSR*, 1957, **116**, 221—224. [Russian] M.F.C.

VOL.
1
1958

395. Determination and use of the sag point as a reference point in the heating of glasses. S. SPINNER, G. W. CLEEK and E. H. HAMILTON, *J. Res. Nat. Bur. Stand.*, 1957, **59**, 227—231. The determination of the sag temperature is rapid and simple, and its use in comparing the properties of different glasses is novel. The sag point is compared with previously defined reference points. M.F.C.

Section D

POLYMERS, ELASTOMERS AND VISCOELASTIC MATERIALS

397. The surface tension of viscous polymers. H. TARKOW, *J. Polym. Sci.*, 1958, **28**, 35. Forest Products Lab., Forest Service U.S. Dept. of Agriculture, Madison, Wisconsin, U.S.A. A procedure is described for measuring the surface tension of polymeric liquids whose bulk viscosity is at least 1500 times that of glycerol. The procedure is based on the determination of the force necessary to separate two spheres held together by the test liquid. A series of silicones was examined. Following a relatively sharp rise in surface tension for the lower members, the rate of increase in surface tension with bulk viscosity is extremely small and seems to be approaching a constant value. Author

398. Diffusion-controlled stress relaxation in polymers—II. Stress relaxation in swollen polymers. HIROSH FUJITH and AKIRO KISHIMOTO, *J. Polym. Sci.*, 1958, **28**, 547. Phys. Chem. Lab., Dept. of Fisheries, Univ. of Kyoto, Maizuru, Japan. Stress relaxation was measured at various temperatures above the glass transition points in polyvinyl acetate and polymethyl acrylate swollen with water and with methanol. It was found that a time-concentration superposition could be applied to these systems to obtain master relaxation curves for the pure polymers at fixed temperatures. These curves were further superposed by a shift along the log-time axis. The concentration shift factor is interpreted in terms of a parameter dependent upon the plasticising effect of a given diluent on a given polymer. D.W.S.

399. Molecular weight distribution by stress relaxation. A. V. TOBOLSKY A. MERCURIO and MURAKAMI, K. *J. Colloid Sci.*, 1958, **13**, 196 (letter). Frick Chemical Lab., Princeton University, Princeton, New Jersey, U.S.A. The distributions of relaxation times, determined from stress relaxation data, for two polystyrene polymers are compared. The polymers are (i) a special polymer prepared by the "living polymer" technique and essentially (monodisperse ($\bar{M}_w/\bar{M}_n \simeq 1{\cdot}1$). (ii) a polydisperse sample ($M_w/M_n = 1.5$). The authors suggest that the stress relaxation measurements can easily distinguish between the two samples. D.W.S.

400. Diffusion-controlled stress relaxation in polymers—III. Stress relaxation in a swelling polymer. AKIRA KISHIMOTO and HIROSHI FUJITA, *J. Polym. Sci.*, 1958, **28**, 569. Phys. Chem. Lab., Dept. of Fisheries, Univ. of Kyoto, Maizuru, Japan. An approximate theory of the relaxation of stress in an amorphous linear polymer above its glass transition

points during sorption of a low molecular weight penetrant is presented. Experimental data for polymethyl acrylate swollen with water and with methanol at 40°C are presented and showed to be in reasonable agreement with the theory. D.W.S.

401. Correlation of dynamic and steady flow viscosities. W. P. Cox and E. H. Merz, *J. Polym. Sci.*, 1958, **28**, 619 (letter). Monsanto Chemical Co., Plastics Div., Springfield 2, Mass., U.S.A. A method of correlating dynamic viscosity vs. frequency plots with steady viscosity vs. rate of shear plots is suggested. Experimental data are presented on two types of polystyrene at temperatures of 400 and 450°F. The correlation is shown to work well for these polymer melts. The correlation is also investigated for measurements on 13% and 20% polyisobutylene in decalin taken from the literature. D.W.S.

402. Equivalent effects of time and temperature in the deformation of elastomers. A. R. Payne, *Plastics, Lond.*, May 1958, 182—184. R.A.B.R.M. Shawbury. Discussion of the use of the Williams, Handel and Ferry method of reducing creep and recovery data to a master curve and the application of the master curve obtained to specific problems (e.g. low temperature stiffness, creep at long time intervals). E.B.A.

403. A study of the elastic modulus and extensibility of the crystalline regions in highly oriented polymers. W. J. Dulmage and L. E. Contois, *J. Polym. Sci.*, 1958, **28**, 275. Eastman Kodak Co., Rochester, New York, U.S.A. In crystalline polymers in which the polymer chains in the crystalline regions are in a contracted configuration these regions may be extensible, their modulus being not much greater than the modulus of the unoriented amorphous regions. In this case the macroscopic elastic modulus is made less dependent upon orientation and degree of crystallinity than for polymers having crystals of very high modulus. Measurements of macroscopic moduli and X-ray measurements of chain contraction in eight polymers have been made and the results are discussed in terms of the properties of the crystalline and amorphous regions. D.W.S.

404. The tensile properties of some plastics at low temperatures. J. Dyment and H. Ziebland, *J. Appl. Chem.*, 1958, **8**, 203—206. Explosives Research and Development Establishment, Waltham Abbey, Essex, Eng. Tensile strengths and Young's modulus were measured at temperatures from +20°C to −196°C for the following plastics: polytetrafluorethylene, polycaprolactam, polyvinyl chloride and polytrifluoromonochloroethylene. E.B.A.

405. An interpretation of the strength properties of amorphous polymers below the glass transformation temperature. R. Buchdahl, *J. Polym. Sci.*, 1958, **28**, 289 (letter). Plastics Div., Monsanto Chemical Co., Springfield, Mass., U.S.A. The theory of the ultimate strength or yield strength developed for crystals is applied to results on six polymers in the glassy state. The agreement between theory and experiment is satisfactory. The theory gives a simple explanation of the variation of the strength of glassy polymers with frequency and temperature. D.W.S.

VOL.
1
1958

406. Thirty years of plastics impact testing—I. R. F. WESTOVER, *Plastics Technol.* April 1958, 223. Polymer Mechanics Section, Bell Telephone Laboratories, Murray Hill, N.J., U.S.A. This first of two parts analyses and discusses past accomplishments in plastics impact testing and begins a discussion of the present status of the field. Factors discussed include Izod and Charpy methods, deformation and fracture of specimens, broken half tossing energy, and effects of blow speed, specimen grip, testing speed and energy losses. Author

407. High-shear-rate rheological properties of plastics. A. C. WERNER, *Mod. Plast.*, 1957, **34**, 137—144, 234—235. This paper reviews and expands upon work with a high-shear-rate extrusion plastometer previously reported (Ind. Eng. Chem., 1954, **46**, 2369) and discusses recent work on the measurement of high-shear-rheological properties of plastisols. D.P.D.

408. Creep relaxation of Plexiglass IIa for simple stresses. J. MARIN and J. E. GRIFFITH, *Proc. Amer. Soc. Civ. Engrs.*, 1956, **82** (EM3) Paper No. 1029. Experimental creep-relaxation results are obtained for simple tension, simple compression, and pure bending. These results are compared with data calculated from constant stress results. Agreement is considered to be satisfactory. D.P.D.

409. Effect of pile irradiation on the dynamic mechanical properties of polythene. C. W. DEELEY, D. E. KLINE, J. A. SAUER and A. E. WOODWARD, *J. Polym. Sci.*, 1958, **28**, 109. College of Chemistry and Physics, Pennsylvania State University, University Park, Pennsylvania, U.S.A. The effects of pile irradiation on the damping and resonant frequency of " high pressure " polythene have been investigated over a temperature range 80 to 550°K in the audiofrequency region using an apparatus which derives rod-like specimens in their transverse modes. D.W.S.

410. Moulding linear polyethylene. A. SPAAK and C. L. WEIR, *Mod. Plast.*, April 1958, 122—125, 128—129. Polymer Chemicals Div., W. R. Grace Co., New York. The spiral mould flow test was used to assess moulding behaviour of linear polythenes of several melt indexes. The results are compared with those for branched polythenes and high impact polystyrene. E.B.A.

411. Creep in polyethylene at elevated temperatures. R. R. DIXON, *S.P.E.J.*, 1958, **14**, 23—24, 70. Westinghouse Electric Appliance Division, Columbus, Ohio, U.S.A. Tensile creep tests were carried out on a Finius-Olsen Plastiversal over a time range of 10—240 min at temperatures of 120 and 150°F and 100 and 300 p.s.i. Low density, Ziegler and Phillips polyethylene and polystyrene were examined.

412. Molecular structure and motion in irradiated polyethylene. W. P. SLICHTER and E. R. MANDELL, *J. Phys. Chem.*, 1958, **62**, 334—340. Bell Telephone Laboratories, Inc., Murray Hill, New Jersey, U.S.A. Data from X-ray diffraction and proton magnetic resonance spectroscopy indicate that, contrary to earlier findings, high-energy irradiation affects both crystalline and amorphous regions of polyethylene. A.S.L.

413. Mechanical properties of thin polyethylene film. A. A. ANDERSON and G. L. MORFITT, *Mod. Plast.*, 1958, 139—148, 222—224. Mechanical Div. of General Mills. Inc. An apparatus is described which was used for determining stress–strain curves of thin polyethylene films at temperatures down to −70°C at elongation rates of 0·03 to 6 in/sec. The force required to peel apart bent sealed film was also measured. A transition in general behaviour at −15 to −45°C is noted. E.B.A.

414. Viscosity and elasticity of gamma irradiated polytetrafluoroethylene above the melting point. KAZUYOSHI MATSUMAE, MUNED WATANABE, ATSUO NISHIOKA and TORAO ICHIMIYA, *J. Polym. Sci.*, 1958, **28**, 655. Electrical Comm. Lab., Nippon Telegraph and Telephone Public Comp., Kichijoji, Musashino, Tokyo, Japan. Experimental data are presented to show that both the viscosity and elasticity of polytetrafluoroethylene above its melting point fall rapidly with increasing doses of gamma radiation. These effects are attributed to the reduction in molecular weight which is known to occur as a result of irradiation. D.W.S.

415. The determination of the stiffness of the chain of a rubber-like polymer. R. S. STEIN, *J. Polym. Sci.*, 1958, **28**, 83. Department of Chemistry, University of Massachusetts, Amherst, Mass., U.S.A. A theory of the infra-red dichroism of a cross-linked, rubber-like amorphous polymer is described. The dichroism of a typical rubber is estimated to be measurable. The dichroism–stress ratio is independent of strain and degree of cross-linking and serves as a measure of the number of monomer units per statistical segment, an index of chain stiffness.
Author

416. Anomalous behaviour of polymer solutions—II. Viscosity behaviour of rubber solutions at high dilutions. S. L. KAPUR and S. GUNDIAM, *J. Colloid. Sci.*, **13**, 170. National Chemical Laboratory, Poona 8, India. Studies in the viscosity of dilute solutions of crepe and deproteinized natural rubber in different solvents have shown that carbon tetrachloride and other chlorinated solvents are not suitable for viscosity determinations of rubber. Data are presented to show that the anomalous increase of viscosity at very high dilutions cannot be explained by Öhrn's absorption hypothesis but could be attributed to the extension and disentangling of polymer chains at higher dilutions. The anomaly is also shown to disappear if the solutions are shaken for a minimum period of time before viscosity determinations. Author

417. Forms for the stored (strain) energy function for vulcanised rubber. A. N. GENT and A. G. THOMAS, *J. Polym. Sci.*, 1958, **28**, 625 (letter). British Rubber Producers Res. Assoc., Welwyn Garden City, Herts, England. A simple empirical form for the stored energy function for a vulcanised rubber is suggested. It is shown that this simple form describes the experimental data more accurately than the simple Mooney form and at least as well as the more complicated form previously suggested by Thomas. D.W.S.

418. Rheological investigations of the mastication of rubber. K. EDELMANN, *Rheologica Acta*, 1958, No. 1, 53—57, 61—63. Fibre Research Institute, Deutsche Akademie der Wissenschaften, Berlin. Samples of smoked sheet rubber, masticated by different amounts, are dis-

solved in toluene at various concentrations. The viscosity of each solution is measured in a capillary viscometer for shear rates in the range 10 to 10^3 sec^{-1}. The curve of log (viscosity) against log (shear rate) for each solution shows the usual point of inflexion ; the shear rate at this point is independent of concentration and is taken to be a measure of average molecular weight ; the slope of the curve at this point is taken to be a measure of polydispersity. [German] A.S.L.

419. The microstructure of crazed plastics. ANON, *Plastics, Lond.*, May 1958, 185. A short review of recent work in the U.S.A. mainly upon crazing of polymethyl methacrylate. Surface topographies have been studied using multiple beam interference microscopy and electron microscopy. 3 references. E.B.A.

420. Dynamic mechanical properties of Nylon 66 and the plasticizing effect of water vapour on nylon. J. M. R. QUISTWATER and B. A. DUNELL, *J. Polym. Sci.*, 1958, **28**, 309. Department of Chemistry, University British Columbia, Vancouver, Canada. The dynamic tensile modulus and energy loss have been measured for nylon 66 at 35°C over a wide range of humidity in forced longitudinal vibration experiments. The frequency range covered was about 3 to 30 c/s. Author

421. A systematic approach to the dynamical testing of high polymer solids—I. Dynamical tensile testing for textiles. F. WINKLER, *Faserforschung*, 1958, **9**, 109—117. Institut für Faserstoff-Forschung in Tetlow-Seehof, Berlin. Oscillatory methods of tensile testing given in the literature (63 references) are classified according to whether the mean stress and amplitude of stress, or the maximum stress and amplitude of strain, or various other similar combinations of variables, are kept constant during the test. It is stated that good reproducibility of test results is obtained when the maximum or minimum value of stress or strain is kept constant, but not when the mean value of stress or strain is kept constant. [German] A.S.L.

422. Relaxation behaviour of monofilaments under simultaneously superposed oscillatory tensile stress. W. MESKAT and W. HOFFMANN, *Rheologica Acta*, 1958, **1**, 77—86. Farbenfabriken Bayer A.G., Leverkusen, Germany. An apparatus is described which records the tension in a monofilament subjected to simultaneous extension at a specified rate and oscillatory extension at specified amplitude and frequency. The observed stress relaxation of a Perlon filament is analysed into a sum of three exponential functions of time ; repetitions with fresh samples give values of the coefficients reproducible to 5% and of the relaxation times, 10%. The effect on these constants of (*a*) repeating the stressing cycle and (*b*) applying an oscillatory extension during relaxation is determined. It is stated that the data obtained have (in contrast to breaking extension data) been successfully correlated with wearing properties of nylon fabrics. [German] A.S.L.

423. Anomalous behaviour of the extinction angle of moderately concentrated polyvinyl alcohol–water solutions. SHOEI FUJISHIGE, *J. Colloid Sci.*, 1958, **13**, 193 (letter). Textile Res. Inst. of Japanese Govt., 4, Sawatari, Kanagawa, Yokohama, Japan. Measurements of extinction angle and flow-birefringence in 5% and 7% solutions of polyvinyl alcohol

in water for shear rates from 300 to 5000 sec^{-1} are presented. The relation between extinction angle and shear rate in the freshly made solutions is markedly different from the relation for solutions 7 days old. The birefringence/shear-rate relations are not so markedly different. All the curves are said to be reversible. A possible qualitative explanation is discussed. D.W.S.

424. Viscoelastic properties of concentrated polymer solutions. TETUO TAKEMURA, *J. Polym. Sci.*, 1958, **28**, 185. Dept. of Appl. Sci., Faculty of Engineering, Kyurhu University, Kyurhu, Japan. Relaxation spectra for concentrated polymer solutions are obtained from a molecular theory based on a network model. Two relaxation mechanisms are considered involving (*a*) vibrational modes between network structures (*b*) vibrational modes of intra-chain sub-molecules in the network. The theory shows that the box-type distribution of relaxation times can be obtained from (*a*) and the wedge type from (*b*). D.W.S.

VOL.
1
1958

425. Viscosity of cellulose nitrate solutions in solvent and solvent–non-solvent mixtures: Dependence of viscosity on rate of shear. A. G. CHITALE, *J. Sci. Industr. Res.*, 1958, **17B**, 60—63. The Ahmedabad Textile Industry's Research Association, Ahmedabad, India. The viscosities of cellulose nitrate (D.P. 1400), measured in ethyl acetate and ethyl acetate–methanol mixtures at different rates of shear using a Ubbelohde dilution viscometer, show that intrinsic viscosity is independent of the rate of shear. Corrections for shear effects are, however, necessary if intrinsic viscosity is calculated on η measurements at a single concentration, For D.P. determinations it is not necessary to determine the intrinsic viscosity at zero rate of shear; any arbitrarily chosen constant rate of shear can be employed. The dependence of the intrinsic viscosity of cellulose nitrate on both shear and concentration is less pronounced in ethyl acetate–methanol mixtures than in ethyl acetate alone. Author

426. Critical concentration effects in polymer-polymer-solvent systems. C. C. BIGELOW and L. H. CRAGG, *Canad. J. Chem.*, 1958, **36**, 199—227. In systems consisting of polymer A, polymer B and solvent S, the relationship of the intrinsic viscosity $[\eta]$ of A in B and S to the concentration c_B of B in S is studied. The $[\eta]$–c_B curve shows a dip if S is good for A, and a peak if S is poor for A. M.F.C.

427. An indication from rheological measurements of the state of solution of xanthate- and organoxanthate-solutions. J. SCHURZ and W. ZIMMERL, *Faserforschung*, 1958, **9**, 151—153. Physical Chemistry Institute, Graz University. The value of the mean shear rate at which the flow curve obtained from a capillary viscometer has a point of inflexion is taken as a measure of the size of the macromolecular particles in solution. The decrease in size with increase of dilution observed with a solution of diethylacetamido cellulose xanthate in ethylene chlorhydrin is attributed to a break-up of macromolecular aggregates. Comparable values for particle size were obtained for the viscose from which the organoxanthate was prepared. [German] A.S.L.

428. On the interpretation of hydrodynamic data for dilute protein solutions. H. A. SCHERAGA and L. MANDELKERN, *J. Phys. Chem.*, 1958, **62**, 370. Cornell University, Ithaca, New York, U.S.A. A brief reply to some recent criticisms. A.S.L.

429. The possibility of interpreting flow curves. J. SCHURZ, *Rheologica Acta*, 1958, **1**, 58—63. Physical Chemistry Institute, Graz University. A brief discussion is given of (i) the correlation between the shear rate at the point of inflexion of a flow curve for a high polymer solution and the mean polymer molecular weight, and (ii) the correlation between the slope at the same point and the polydispersity. [German] A.S.L.

430. Viscosity–molecular weight relationships for cellulose acetate. W. R. MOORE and B. M. TIDSWELL, *J. Appl. Chem.*, 1958, **8**, 232—237. Dept. of Chemistry and Dyeing, Bradford Inst. of Technology. Fractions obtained from a commercial cellulose acetate (acetic acid yield 53·7%) were used. Molecular weights determined from osmotic pressure. The constants K and a in the equation $[\eta]=KM^a$ were found to be for various solvents. Acetone : $K=2\cdot8$, $a=0\cdot78$; Methyl acetate : $K=2\cdot7$, $a=0\cdot79$; Acetic acid : $K=6\cdot5$, $a=0\cdot72$; Pyridine : $K=12\cdot1$, $a=0\cdot63$; Aniline : $K=3\cdot9$, $a=0\cdot76$ (values of $K\times10^4$). E.B.A.

431. Relation between viscosity and molecular weight of ethyl cellulose. W. R. MOORE and A. M. BROWN, *J. Appl. Chem.*, 1958, **8**, 363—367. Department of Chemistry and Dyeing, Bradford Institute of Technology, England. Commercial samples of ethyl cellulose (ethoxyl contents 48·2 and 48·5%) were fractionated. Molecular weights were determined osmotically using methyl ethyl ketone as solvent. Intrinsic viscosities were determined in methyl ethyl ketone, ethyl acetate, *n*-butyl acetate, benzene and chloroform and the constants in the expression $[\eta]=KM^a$ determined for each solvent. E.B.A.

Section E

PASTES AND SUSPENSIONS

432. A new rheological classification for pigment suspensions in polymer solvents. L. DINTENFASS, *J. Appl. Chem.*, 1958, **8**, 349—351. Taubmans Industries Ltd., St. Peters, New S. Wales. A classification is proposed depending upon the state of the pigment (dispersed or flocculated) and upon the state of the vehicle (dispersed, aggregated or aggregated with a network structure). Newtonian, thixotropic and dilatant behaviour depend both upon the nature of the vehicle and the state of dispersion of the pigment and may change with temperature or rate of shear. Twelve distinct types of behaviour occur in actual paint systems when viscosity is determined over a wide range of shear rates (0·01–100 sec^{-1}) and which may be classified according to the proposed scheme. E.B.A.

433. The rheological properties of stable suspensions of very small spheres at low rates of shear. G. A. EVESON, *J. Oil Col. Chem. Ass.*, 1957, **40**, 456—477. A rotational viscometer has been used to investigate, at rates of shear between 0·05 and 1·10 sec^{-1}, the rheological properties

of stable suspensions of nine sized fractions of spheres, eight of these being in the sub-sieve range (below 60 microns). The influence of the degree of flocculation or dispersion and of the electrical state of the particles is considered. It is suggested that for a given zeta-potential flocculation will occur if the average distance between sphere surfaces is less than a critical value. The relative viscosity of Newtonian stable suspensions of spheres is independent of mean particle diameter for spheres above about 15 microns but for smaller particles increases with decreasing mean diameter. D.P.D.

434. Turbulent flow of suspensions in tubes. A. D. MAUDE snd R. L. WHITMORE, *Fluid Handl.*, 1958, No. 97, 41—42, 45. Dept. of Mining and Fuels, Nottingham University, England. The apparatus and test method are described of an experiment in which aqueous suspensions of fine, graded emery powder were forced through narrow vertical tubes at various concentrations and rates of flow. Curves of friction factor against Reynolds number were plotted. (Account of paper presented to a meeting of the Institute of Chemical Engineering, Feb. 4th, 1958.)

VOL.
1
1958

435. The mixing of slurries. K. N. LEIBOVIC, *Indust. Chem.*, 1957, **33**, 452—456. Describes the mixing of non-Newtonians fluids, particularly wood pulp slurries. Expressions are derived for the maximum power needed for mixing, and for the rate of disintegration of the pulp. The problem of dynamical similarity between systems of this sort is discussed. M.F.C.

436. Influence of foaming on rate of flow. W. F. DAGGETT, *Paint Manuf.*, 1958, **28**, 158. It is stated that air bubbles in a lacquer have no effect on viscosity determinations by flow cup at room temperature (and, that " the addition of defoaming agents to beer is quite unnecessary in order to ensure the consumption of the maximum quantity in the minimum time ".) R.J.C.

437. Turbidity and viscosity measurements on some cationic detergents in water and in sodium chloride solutions. L. M. KUSHNER, W. D. HUBBARD, and R. A. PARKER, *J. Res. Nat. Bur. Stand.*, 1957, **59**, 113—119. The detergents were dodecylamine hydrochloride, dodecyltrimethylammonium chloride, and tetradecyltrimethylammonium chloride. The micellar weight and intrinsic viscosity of the micellars were calculated, and the dependence of these quantities on the concentration of sodium chloride is discussed. M.F.C.

438. The rheological properties of surface layers at the oil–water interface and their role in the stability of oil emulsions. M. M. KUSAKOV and A. A. PETROV, *Dokl. Akad. Nauk SSSR*, 1957, **116**, 637—640. [Russian] M.F.C.

439. The movement of the shaft body through drilling mud during the process of shaftmaking. P. G. MEERMAN, *Rheologica Acta*, 1958, No. 1, 28—32. Mining Research Institute, Limburg, Treebeck, Holland. The drilling mud is represented as a Bingham body ; it is shown that the yield stress must not exceed a few dynes per sq. cm if the shaft body is to sink sufficiently easily through the drilling mud. [German]

440. On the nature of the dispersion in plastic clays. I. A. ALPEROVICH and Pl P. BUDNIKOV, *Dokl. Akad. Nauk SSSR*, 1957, **116**, 463—466. M.F.C.

441. The electroviscous effect in solutions of silver iodide. A. J. RUTYERS and P. NAGELS, *J. Colloid Sci.*, 1958, **13**, 148. University of Ghent, Belgium. The electroviscous effect has been measured in a H-sol. of Ag I to which 0—10 millimole/l. of KNO_3 had been added. The results are interpreted with the theory of Booth, which gives satisfactory results. Author

442. Roof coating asphalts. C. E. WILKINSON, L. STRIKER and R. N TRAXLER, *A.S.T.M. Bull.*, 1958, No. 230, 42—44. Texaco Port Arthur-Port Neches Res. Labs., Port Neches, Texas. Describes physical evaluation tests to determine suitability of asphalts for roof coating. Rheological tests include softening point and indentation tests. E.B.A.

443. Investigations of the rheologic properties of mastic asphalt, of the development of cracks in mastic asphalt roofs, and of the progressive opening of the cracks. J. M. KIRK, *Acta polyt., Stockh.*, 1956, 193. Civil Engineering and Building Construction Series, **3(4)**. The rheological properties of asphalt mastics were studied in the Danish State Road Laboratory, by measuring the deflection curves of mastic asphalt bars at different temperatures. From the data an equation has been developed for calculating approximately the tensile stresses in mastic asphalt during cooling. D.P.D.

444. The mechanical and rheological properties of bitumen. O. KIRSCHMER, *Bitumen, Hamburg*, 1956, **18**, 89—92. After defining the terms used, flow is described in the following: an ideal elastic body, a plastic body, a Newton fluid, a Maxwell fluid (elastico-viscous behaviour). The Maxwell equation is applied to bitumen and illustrated by a mechanical model. Prandtl's atomic theory is discussed. 18 references. D.P.D.

445. Thermoplasticity and structural viscosity of bitumen and similar thermoplastic materials. F. HEMPEL, *Bitumen, Teere Asphalte u Peche*, 1957, **8**, 311—316. Berlin. On the co-ordinates log log viscosity against log absolute temperature straight lines are obtained for bitumens. The viscosity values can be calculated for either constant shear stress τ or constant rate of shear dv/dy; the values differ if the material shows structural viscosity. The negative slope of the straight line for τ constant gives the temperature susceptibility or Plasticity Index. The ratio of the slope for τ constant to the slope for dv/dy constant gives a measure of structural viscosity and is called the Relative Thermoplasticity. A brief description is given of the viscometer used. [German] J.F.H.

Section F

LIQUIDS

446. Bulk viscosity of liquids. N. HIRAI and H. EYRING, *J. Appl. Phys.*, 1958, **29**, 810–816. University of Utah, Salt Lake City, Utah, U.S.A. The mechanisms for bulk viscosity are different between associated and

non-associated liquids. Here a new mechanism for bulk viscosity is proposed from the standpoint of the hole theory of liquids and the rate process theory. This mechanism can explain the temperature and pressure dependencies of acoustic absorption for associated liquids and very viscous non-associated liquids. Author

447. Viscosity of liquid helium II near the lambda point. J. G. DASH, *Phil. Mag.*, 1958, **3**, 586—590. Royal Society Mond Laboratory, Cambridge, England. The theory of Landau and Khalatnikov for the viscosity of liquid helium II is examined in the neighbourhood of the lambda point. Arguments are advanced against the validity of the ideal gas approximation for rotons, and a quantitative roton liquid model is proposed. The temperature dependence of viscosity of the liquid model is found to correspond to the observed viscosity above 1·8°K, and with the discontinuity in the temperature derivative of viscosity at the lambda point. Author

VOL.
1
1958

448. Turbulent viscosity in a shallow sea, due to waves. O. D. SHEBALIN, *Dokl. Akad. Nauk SSSR*, 1957, **116**, 591—594. [Russian] M.F.C.

449. On the low-temperature properties of silicone oils (dimethylpolysiloxanes). W. WEBER, *Rheologica Acta*, 1958, **1**, 63—69. Physikalish-Technischen, Bundesanstalt, Braunschweig, Germany. Using capillary viscometers, low-viscosity methyl silicones were found to solidify gradually as the temperature was lowered and remained Newtonian down to −120°C; higher-viscosity methyl silicones solidified sharply below −40°C and exhibited non-Newtonian behaviour. The temperature-dependence of viscosity was determined up to 100°C. [German] A.S.L.

450. Unsteady flow of viscous fluid between parallel porous walls. D. E. DOLIDZE, *Dokl. Akad. Nauk SSSR*, 1957, **117**, 380—383. M.F.C.

451. Speed of sound in water by a direct method. M. GREENSPAN and C. E. TSCHIEGG, *J. Res. Nat. Bur. Stand*, 1957, **59**, 249—254. The speed of sound in distilled water was measured over the temperature range 0° to 100°C with an accuracy of 1 part in 30,000. The water was contained in a cylindrical tank of fixed length, terminated at each end by a plane transducer. The end-to-end time of flight of a pulse of sound was determined from a measurement of the pulse-repetition frequency required to set the successive echoes into time coincidence. M.F.C.

452. The effect of maldistribution on the performance of packed columns. *v.* W. MULLIN, *Industr. Chem. Mfr.*, 1957, **33**, 408—417. A discussion of the distribution of liquid flow in distillation columns and its bearing on their performance. A theoretical treatment is included. M.F.C.

453. A consideration of the thermal treatment of wells in mineral oil deposits. H. BERNHARD, N. LINDEMANN and H. MEDER, *Erdöl u. Kohle*, 1958, **11**, 231—234. Preussiche Bergwerks-und Hutten-AG, Hannover. Since the viscosity of oils decreases rapidly with increase in temperature the production rate of a well is expected to be favourably influenced by heating the oil deposit in the well's vicinity. To obtain estimates of the increase in delivery rate and the energy required, the Darcy equation with a variable viscosity term must be used and the distribution of heat around the well calculated with the aid of an electrical analogy. Field trials confirm the results of the calculations. [German] Author

Section G

GENERAL

454. On the question of rheological nomenclature. P. G. MEERMAN, *Rheologica Acta*, 1958, No. 1, 86—87. Secretary, Nederlandse Reologische Verenigung. In preparation for a proposed discussion at the forthcoming Third International Congress on Rheology, a brief outline of the principles underlying the Dutch proposals on nomenclature is given. A new edition of these proposals is in the press. [German] A.S.L.

455. Unlike molecular interactions and properties of gas mixtures. K. P. SRIVASTAVA, *J. Chem. Phys.*, 1958, **28**, 543—549. Indian Association for the Cultivation of Science, Calcutta 32. Transport properties (e.g. thermal diffusion, interdiffusion, thermal conductivity and viscosity) have been calculated for a large number of binary mixtures on the basis of a Buckingham intermolecular potential. Agreement between theory and experiment is quite satisfactory. E.B.A.

456. Continuous stream analysis—Your key to process profits. D. J. FRAADE, *Process Control*, 1957, **4**, 269—274. Conclusion to previous article, describing methods of measuring continuously the physical properties of flowing media. M.F.C.

LIST OF JOURNALS COVERED FOR RHEOLOGY ABSTRACTS

Analyt. Chem.
Ann. N.Y. Acad. Sci.
Appl. Sci. Res., Gravenhage.
Arch. Mech. Stosowanej.
A.S.T.M. Bull.
Aust. J. Appl. Sci.
Aust. J. Phys.

Bitumen, Teere, Asphalte u. Peche
Brit. Chem. Engng.
Brit. J. Appl. Phys.
Brit. Plast.
Brot. u. Gebäck.
Bull. Acad. Sci. U.R.S.S.
Bull. Amer. Ceram. Soc.

Canad. J. Chem.
Canad. J. Phys.
Cereal Chem.
Chem. Rev.
Chim. et Industr.
Clays and Clay Min.
Clay Min. Bull.
Coll. Trav. Chim. Tchécosl.
C.R. Acad. Sci.

Dairy Ind.
Diss. Abs.
Dokl. Akad. Nauk SSSR
DSIR Contents List

Engineer, Lond.
Engineering, Lond.
Erdöl u. Kohle

Faserforschung
Fluid Handling
Food Tech.

Glass Ind.
Glastech. Ber.
Glyce ine News

Helv. Chim. Acta.
Helv. Phys. Acta.

Ind. Eng. Chem.
Indust. Chem.
Instrum. Pract.

J. Amer. Ceram. Soc.
J. Amer. Chem. Soc.
J. Amer. Leath. Chem. Ass.
J. Amer. Oil Chem. Soc.
J. Appl. Mech.
J. Appl. Phys.
J. Ceram. Ass. Japan
J. Chem. Educ.
J. Chem. Phys.
J. Chem. Soc.
J. Chim. Phys.
J. Colloid Sci.
J. Dairy Res.
J. Dairy Sci.
J. Fluid Mech.
J. Franklin Inst.
J. Imp. Coll. Chem. Engng. Soc.
J. Inst. Fuel
J. Inst. Met.
J. Inst. Petrol
J. Mech. Phys. Solids
J. Oil Col. Chem. Ass.
J. Phys. Chem.
J. Polym. Sci.
J. Rat. Mech. Anal.
J. Res. Nat. Bur. Stand.
J. Sci. Fd. Agric.
J. Sci. Industr. Res.
J. Sci. Instrum.
J. Soc. Dy. Col.
J. Soc. Glass Tech.
J. Soc. Leath. Tr. Chem.
J. Soil Sci.
J. Text. Inst.

Kolloidnyĭ Zh.
Kolloidzschr.
Kunststoffe

Lab. Practice
Lubric. Engng.

Mod. Plast.

Nature, Lond.
Neftyanoe Khoz.
NLGI Spokesman
Nuovo Cim.

Oil Ind., Moscow

Paint Manuf.
Paint Tech.
Petrol Engr.
Petrol Process.
Petrol Refin.
Petroleum, Lond.
Phil. Mag.
Phil. Trans.
Phys. Rev.
Plastics, Lond.
Plastics Tech.
Proc. Camb. Phil. Soc.
Proc. Phys. Soc. Lond.
Proc. Roy. Soc.
Proc. Soil Sci. Soc. Amer.
Process Control

Quart. Appl. Math.

Research, Lond.
Rev. de l'Inst. franç. du pétrole
Rev. Mod. Phys.

VOL.
1
1958

LIST OF JOURNALS COVERED FOR RHEOLOGY ABSTRACTS

Rev. Sci. Instrum.
Rubb. Chem. Technol.

Sci. Lubric.
Silicates Industr.
Soil Sci.
Sov. Phys. JETP
S.P.E.J.
Svensk Pappers Tidning

Tappi

Text. Res. J.
Trans. Brit. Ceram. Soc.
Trans. Faraday Soc.
Trans. Plast. Inst., Lond.
Trans. Soc. Rheol.

Verres et Réfr.

Wire Ind.
Wire Prodn.
Wire and Wire Prodn.

OL.
1
958

Summaries of papers read at the Symposium on the accurate measurement of the viscosity of liquids, held jointly by the Institute of Petroleum and the British Society of Rheology, 6th June, 1958, at the Institute of Petroleum, 61 New Cavendish Street, London, W.1.

VOL.
1
1958

The Determination of Viscosity by the Oscillating Vessel Method

By R. Roscoe, King's College, Newcastle-upon-Tyne

Further development of accurate absolute methods of viscosity measurement is desirable, particularly for the determination of the viscosity of liquids suitable as standards in viscometry. The principal difficulty in the capillary tube method lies in the elimination of the end correction, and this necessitates the use of two tubes of different length with identical ends. It appears that the slight inconsistencies in the very careful measurements of Swindells, Coe and Godfrey (who found the viscosity of water at 20°C to be 1·001 9 ± 0·000 3 cP) arise from small differences in the ends of paired tubes.

The oscillating vessel method, advocated by Andrade and Chiong, may therefore prove to be better for accurate work. Here the liquid is contained in an axially symmetrical vessel held by a torsional suspension and set in rotation about a vertical axis. The viscosity can be obtained (by a rather complicated calculation) from observations on the logarithmic decrement and time period of the system. A new and accurate method of calculation for use with spherical, nearly spherical and cylindrical vessels is discussed briefly, as is the effect of external air resistance.

Theoretical considerations show that the amplitude of the oscillations must be small for accurate work. The method has been used in some new measurements on the viscosity of water made in collaboration with Mr. W. Bainbridge which will be published in detail elsewhere. A spherical vessel was used with a graduated capillary tube as its stem, so that the water acted as its own thermometer. The result obtained was 1·002 5 ± 0·000 5 cP. An analysis of the sources of error in this result suggests that, with fairly simple improvements in technique, the accuracy of the method could be made substantially greater than that attained in capillary tube measurements. Among suggested improvements are the use of a cylindrical vessel and the determination of the logarithmic decrement from measurements of angular velocity rather than amplitude of oscillation.

Measurement of Viscosity by an Electronic Counting Technique

By M. T. Browne (Imperial College and Queen Elizabeth College)

The viscosity is derived from measurements of the damping of a vibrating system, a beryllium–copper rod, 12 in. long by $\frac{3}{8}$ in. diameter held centrally by four screws, immersed in the medium, the measurements being made by means of an electronic counting technique.

For small values the logarithmic decrement is $\delta \simeq \Delta W/2W$ where ΔW is the energy absorbed in each cycle of vibration and W is the total energy of vibration.

To calculate the damping arising from the viscous resistance of the fluid medium it is necessary to evaluate the " surface loading " which is completely specified by the driving point impedance of the medium, Z_0 = amplitude of shear stress/partical velocity, which may, in general, be written $Z_0 = R_0 + iX_0$. The real component R_0 results from a truly resistive force in phase with the particle velocity while x_0 is the out of phase component. Thus, for a rod in torsional free-free vibration, held vertically, and immersed in a fluid medium to a depth y, the resultant logarithmic decrement is

$$\delta_T^y = \frac{2nR_0}{wl\rho_s}\left[1 + \frac{2}{r}\left(y + \frac{l}{2n}\sin\frac{2ny}{l}\right)\right] \qquad (1)$$

where w is the angular frequency, l the length and r the radius of the rod and ρ_s the density of the material.

The relation between R_0 and viscosity, η, for plane shear wave propagation in an infinite viscous medium of density ρ, is $R_0 = (w\rho\eta/2)^{1/2}$.

If the liquid is in the form of a thin film some energy may be reflected back from the boundary. If the surface of the film is free

$$R_0 = \left(\frac{w\rho\eta}{2}\right)^{1/2}\frac{1}{2}\left[\frac{\sinh 2\theta - \sin 2\theta}{\cos^2\theta + \sinh^2\theta}\right]$$

but if the surface is bounded by a solid

$$R_0 = \left(\frac{w\rho\eta}{2}\right)^{1/2} 2\left[\frac{\cos^2\theta + \sinh^2\theta}{\sinh 2\theta - \sin 2\theta}\right] \qquad (2)$$

where $\theta = (w\rho/2\eta)^{1/2}\, t$ and t is the film thickness.

The beryllium–copper rod is driven in its fundamental torsional mode by the interaction of an alternating current in a coil wound in grooves in the surface of the rod and a transverse magnetic field. A similar coil wound orthogonally to the first acts as a pick-up coil and feeds a decaying voltage to the electronic apparatus when the " drive " is switched off. The electronic apparatus is actuated and counts the number of cycles of vibration (N) occurring while the amplitude decreases from one value to half this value; thus the log. dec. $\delta = \dfrac{\log_e 2}{N}$

The experiments with this apparatus have been used to confirm the form of equation (1) and (2) and to calculate viscosity ; with water the results agreed with the accepted static viscosity to within 1%.

With a higher viscosity liquid a drop was located on a plane end of the rod and the results agreed to within 3% of the standard values. The range of frequency that could be covered by this apparatus, determined principally by the natural frequency of the chosen vibrating systems, is of the order 1–100 kc/s.

The apparatus is particularly adapted to measure small changes of viscosity if these can be induced without altering the conditions of the vibrating system.

VOL.
1
1958

Viscosity Measurements at High Rates of Shear

By Robert Schnurmann (Esso Research Limited)

Industry has become " shear " conscious during the last two decades mainly in connection with the requirements of the armed services and the automotive industry. At the rates of shear at which viscosities are usually measured the viscosity of liquids does not show variations, but when the rate of shear reaches large values the coefficient of viscosity is no longer a constant ; appreciable flow orientation of the molecules takes place with the immediate practical result of a temporary viscosity reduction while the shearing stress persists, accompanied by a decrease of the viscosity-temperature coefficient. If sufficiently large long chain molecules are in the liquid high shearing stresses will bring about a permanent viscosity loss. Under laminar flow conditions it has been necessary to attain rates of shear of more than $1{\cdot}6 \times 10^6$ sec^{-1} to break down molecules of molecular weights of 25,000, whilst larger molecules of molecular weights of 100,000 can already be broken down at mean rates of shear of the order of 10^5 sec^{-1}.

It is important to be able to measure viscosities at these high rates of shear which occur in practice in hydraulic mechanisms and in closely fitting bearings. At these high rates of shear of the order of 10^5 sec^{-1}, experimental conditions must be established so that the sheared liquid suffers no heating, all the mechanical energy being used to shear the liquid. This is an important point because high shearing stresses can be produced by a variety of means but most of these involve appreciable temperature rise. The complication of heating by friction forces is practically eliminated when a liquid is forced slowly and in individual drops through a narrow streamlined constriction, which behaves effectively like a short capillary of a length-to-diameter ratio of about 2·5. By varying the pressure difference across this aperture between about 5 mm. Hg and 760 mm. Hg at a given temperature of the liquid in the reservoir, or by varying the temperature, the rate of shear can be altered within wide limits. The kinetic energy correction for this " jet viscometer " can be determined experimentally, and is smaller by a factor of about 2 than for long capillary viscometers which usually have a length-to-diameter ratio of 100.

The viscosity of any liquid containing elongated molecules—even quite short—can be made to show a temporary viscosity reduction. Castor oil, for example, appears to have a constant viscosity coefficient for rates of shear up to 5,000 sec^{-1}, yet at a rate of shear of 250,000 sec^{-1}, its viscosity is reduced by about 25%.

The apparent viscosity has, over a wide range of rates of shear, a falling characteristic with a point of inflexion. The curve bends upward when an appreciable proportion of the pressure-volume energy is converted into kinetic energy and when turbulent flow takes place. Thus, to assess quantitatively the temporary viscosity reduction for any particular value of the rate of shear, and to determine the critical Reynolds' number, the kinetic energy correction must be applied to the experimental results. It has been shown that the critical Reynolds' number depends upon the length of the largest molecules in the liquid, their concentration and the rate of shear.

The viscosity of a liquid which has suffered a permanent viscosity loss through severe shearing is more sensitive to temperature change than that of the liquid at low rates of shear. On the other hand, when a liquid suffers a temporary viscosity reduction its viscosity-temperature coefficient is smaller while a shearing stress is applied than when the stress has been removed.

A Short Report on the Standard Methods of Measuring Viscosity in c.g.s. Units

By W. Jennings (National Physical Laboratory) and E. W. J. Mardles (Chairman of Viscosity Panel, Institute of Petroleum)

The revised standards of measuring the viscosity of liquids in c.g.s. units incorporate the experience and the results of co-operative experimental work obtained in this and other countries during the post war years.

The opinion expressed by Dr. Guy Barr, at the first World Petroleum Congress 1933, that the international standardization of viscosities should be made with viscometers of known characteristics, as these are much less likely to change than standard viscosity oils, has been confirmed by the findings of the viscosity committees. The recommendations of the joint meeting of the Institute of Petroleum and the British Society of Rheology, June 1945 (I.P. Journal 31, No. 26, August, 1945) have been implemented and the practical findings used in the compilation of the revised standards. These specify acceptable types of instruments, course of procedure and a "step-up" method of calibration, rigid cleaning and filtering processes, a high precision in temperature control and timing, methods of calculating the coefficient of viscosity from flow times while information is included relating to the effect of air buoyancy, change in gravity and of other factors.

An account is given of the results obtained at the National Physical Laboratory when putting into practice the methods of glass capillary viscometer calibrations and viscosity measurement given in standards B.S. 188 : 1957 and I.P. 71/58. The establishment of a series of reference viscometers on the basis of the agreed viscosity value of water is described. The accuracy of the method is assessed by cross checks with other laboratories. A summary of results obtained during routine calibrations of viscometers for industry is included and a simplified method of calculation for this type of work described.

Measurement of the Viscosity of Polymers at Extremely Low Concentrations

By P. P. RUTHERFORD (University College of North Staffordshire)

Viscosity measurements for several polystyrenes in a series of different solvents at 15° and 25°C. using a U-tube capillary viscometer, gave anomalous $\eta sp/c$ and ln $\eta r/c$ values at the highest dilutions. For polystyrenes of molecular weight less than 40,000, upswings in the graphs were observed when the above values were plotted against the concentration over the range 0·2 to 0·4 g of polymer per 100 ml of benzene at 25°. The concentration at which these upswings occurred depends on (*a*) the intinsic viscosity or molecular weight, (*b*) the temperature and (*c*) the kind of solvent used.

Control methods and the procedure of precise measurement with results for specially prepared polymers are given ; the repeatability was of the order 0·1%.

The flow times for the dilute solutions left in contact with powdered glass for several months were found to be almost unaltered indicating that adsorption effects are negligible. The anomalous behaviour of polymers at low concentration and the dependence of this concentration on the intrinsic viscosity of the polymer are real effects, but before any conclusion can be drawn it is necessary to continue the work not only by viscosity measurements on a series of fractionated polystyrenes of low molecular weight but by the measurement of other properties, such as, for example, light scattering and density in the low concentration range.

The Precise Measurements of Viscosity in the Petroleum Industry

By K. A. LAMMIMAN and P. R. MORRIS, Esso Research Ltd., Abingdon, Berks.

The methods now used in the Petroleum Industry for determining viscosity are mainly based on measuring the rate of flow of liquids through glass capillary tubes. The change from the empirical methods of Redwood and Saybolt was made about 1930, when it became apparent that such methods could not be improved sufficiently to give the degree of precision required for modern process control work.

VOL.
1
1958

Most of the apparatus for kinematic viscosity measurements at standard temperature of −40°F, 100°F and 210°F has become common to all petroleum laboratories. Suspended level, Ostwald U-tube and Cannon–Fenske U-tube viscometers are those usually employed, while specially designed viscometers in which the liquid flows upwards over a clean glass surface are available for testing opaque liquids. Special viscometers are also used for testing small quantities of oil, in the order of 5ml.

Thermostatic baths for holding these viscometers are now obtainable from manufacturers who specialise in their construction. Temperature control is of the greatest importance and special precautions, such as shielding from sunlight, are well recognised. At low temperatures, control can best be achieved by withdrawing heat at a constant rate by means of a refrigerator and then attaining the desired temperature by using heaters controlled from a platinum resistance thermometer.

Other factors beside temperature variation, which may produce appreciable errors are : method of sample preparation, viscometer cleaning, and measurement of time. Errors from the latter variable can be considerably reduced by using an electronic timer. It is also possible to employ viscometers with built-in electrodes, enabling the timing process to be made semi-automatic.

It is customary to determine the precision of reproducibility of a test method by the repetitive testing of a standard product submitted unknown to the laboratory. An analysis of viscosity values obtained on lubricants, fuel oils, diesel fuels and kerosines tested in this way showed that the reproducibility of the viscosity results in the higher viscosity ranges compared well with the data published by the Institute of Petroleum.

Great care must be exercised when testing kerosines and diesel fuels to ensure that the samples are dry and free from particulate matter, as the measurements made by necessity in narrow diameter capillary tubes, can easily be affected by particles obstructing the capillary. For fuels in these low viscosity ranges the Institute of Petroleum give the reprodubibility as 0·25%. It is believed that under normal laboratory conditions it would be more realistic to expect the reproducibility to be nearer the value of 0·5%.

An adaption of the standard kinematic methods used in the petroleum industry has enabled measurements of viscosity to be made at temperatures up to 600°F. The necessary thermostatic bath is constructed so that when the viscometer and temperature control equipment are placed in position the bath fluid is sealed from contact with the air. Another modification finds use for measuring the viscosity of a single drop of oil. In this method, the time for the single drop of oil to flow through a capillary tube surrounded by a constant temperature jacket and tilted at various angles, is measured. The method is accurate to about 5%, which is reasonable for such small amounts of liquid where the effects of surface tension and drainage can become significant.

Further developments of the kinematic viscosity test will no doubt be made to extend the temperature range over which routine measurements are made and it may be expected that many of the manipulative stages will come to be performed automatically.

EDITED PROCEEDINGS OF THE

SECOND INTERNATIONAL CONFERENCE ON THE PEACEFUL USES OF ATOMIC ENERGY, GENEVA,

SEPTEMBER 1958

Editorial Advisory Group :
D. I. BLOKHINTSEV
J. V. DUNWORTH
D. J. HUGHES
I. I. NOVIKOV
F. PERRIN
A. M. WEINBERG

PERGAMON PRESS is pleased to announce that the Board of Editors of Progress in Nuclear Energy, the International Review Series in Atomic Energy, have made arrangements to publish the Edited Proceedings of the Second International Conference on the Peaceful Uses of Atomic Energy in twelve separate volumes, similar to those edited by them and published by Pergamon Press on the First International Conference on the Peaceful Uses of Atomic Energy held in Geneva in 1955.

All volumes will be published and distributed between December 1958 *and April* 1959. *In order to ensure receipt of copies immediately upon publication, please place your order now.*

Customers who have already a standing order for the Progress in Nuclear Energy Series will automatically receive the appropriate volumes.

Price :—

Single volumes £5 5s. 0d. net ($15.00)

Complete set of 12 volumes
£63 net ($180.00)

An 8-page brochure, describing in full detail the Edited Proceedings, is supplied free, on request. Please write to :

PERGAMON PRESS
4 & 5 Fitzroy Square, London W.1

Title of Volume	*Series No.*	*Editors and Location*
Physics and Mathematics.	I	D. J. Hughes, *Brookhaven.* J. E. Sanders, *Harwell.* J. Horowitz, *Saclay.*
Reactors.	II	N. L. Franklin, *Risley.* B. I. Spinrad, *Argonne.*
Process Chemistry	III	F. R. Bruce, *Oak Ridge.* J. M. Fletcher, *Harwell,* H. H. Hyman, *Argonne.*
Technology and Engineering.	IV	R. Hurst, *Dounreay.* R. N. Lyon, *Oak Ridge.*
Metallurgy and Fuels.	V	H. M. Finniston, *Harwell.* J. P. Howe, *Canoga Park, California.*
Biological Sciences.	VI	J. Bugher, *Rockefeller Foundation.* J. Coursaget, *Saclay.* J. F. Loutit, *MRC Harwell.*
Medical Sciences.	VII	J. Bugher, *Rockefeller Foundation.* J. Coursaget, *Saclay.* J. F. Loutit, *MRC Harwell.*
Economics of Nuclear Power.	VIII	J. A. Lane, *Oak Ridge.* P. W. Mummery, *Harwell.* I. R. Maxwell, *London.* Philip Sporn, *New York.*
Analytical Chemistry	IX	Editors being appointed.
Law and Administration	X	Herbert S. Marks, *Washington D.C.*
Plasma Physics and Thermo-Nuclear Research.	XI	J. L. Tuck, *Los Alamos.* C. Longmire, *Los Alamos.* W. B. Thompson, *Harwell.*
Health Physics.	XII	Karl Z. Morgan, *Oak Ridge.* W. G. Marley, *Harwell.*

Some of the Topics to be covered in these Edited Proceedings :

The Future of Nuclear Power. Experience with Nuclear Power Plants. The Use of Nuclear Energy for purposes other than the generation of electricity (for example, Marine Propulsion). The Possibility of Developing Thermo-Nuclear Power (by fusion instead of fission). Progress in the Use of Radioactive Isotopes. Operational Aspects in Health and Safety. Aspects in Nuclear Power Programmes. Recent Developments in Fundamental Physics. Reactor Technology and Chemistry. Properties of Reactor Materials. Treatment and Handling of Radioactive Wastes. Processing of Irradiated Fuel Elements. Problems in Nuclear Fusion. Fuel Cycles and Economics of Nuclear Power. Use of Research and Test Reactors and Reactor Experiments. Dosimetry and Standards. New Uses of Isotopes in Medicine. Use of Isotopes in Biochemistry and Physiology. Use of Isotopes in Research, Control and Industrial Technology. Use of Isotopes in Agriculture. Experience in Radiological Protection. Biological Effects of Radiation. Fabrication of Fuel Elements including the Metallurgy of Uranium, Thorium, Plutonium and their Alloys.

LONDON NEW YORK PARIS LOS ANGELES

122 East 55th Street, New York 22, N.Y. 24 Rue des Écoles, Paris, V^e.

VOL.
1
1958

PRINTED IN GREAT BRITAIN BY METCALFE & COOPER LTD., 10-24, SCRUTTON STREET, LONDON, E.C.2

OL.
1
958

VOL.
1
1958

Section A

THEORETICAL

457. General relationships between the elastic constants of isotropic materials in n dimensions. N. W. TSCHOEGL, *Aust. J. Phys.*, 1958, **11**, 154—157. The relationships between the elastic constants of homogeneous isotropic materials in n dimensions are derived and are shown to depend on n. The maximal value of the generalized Poisson's ratio is $1/(n-1)$. The n-dimensional formulae reproduce the well-known three-dimensional relations for $n=3$, while $n=2$ produces the relations appropriate for monomolecular films. The correct degeneration is shown for $n=1$. Author

458. Relation between stresses and strains in non-elastic media. A. A. VAKULENKO, *Dokl. Akad. Nauk SSSR*, 1958, **118**, 665—668.

459. Dynamic properties of resilient materials : constitutive equations. J. E. ADKINS, *Phil. Trans.* A, 1958, **250**, 519—541. Welwyn Garden City, Herts. (Now at the University of Nottingham). Constitutive equations are formulated for a class of materials for which the stress distribution at any instant is assumed to depend both upon the deformation and upon the time rates of variation of the tensor defining it. Particular attention is given to aeolotropic bodies, the stress deformation relations for orthotropic and transversely isotropic materials being put in forms which exhibit the symmetry properties of the material. In the discussion of symmetry properties, attention is confined to the case where the stress tensor is a polynomial function of two only of the kinematic tensors. Author

460. An application of the method of approximations to the calculation of flow of dispersed systems. N. V. TYABIN and G. V. VINOGRADOV, *Kolloidnyi Zh.*, 1957, **19**, 505. [Russian]

461. The stability of viscous flow between rotating cylinders. S. CHANDRASEKHAR, *Proc. Roy. Soc.* A, 1958, **246**, 301—311. Enrico Fermi Institute of Nuclear Sudies, University of Chicago. An analysis of the general problem of a wide annular gap is given. Numerical results are obtained for the case when the ratio of the radii of the two cylinders is one-half. J.R.J.

462. Experiments of the stability of viscous flow between rotating cylinders—I. Torque measurements. R. J. DONNELLY, *Proc. Roy. Soc.* A, 1958, **246**, 312—325. Institute for the Study of Metals, University of Chicago. The author describes experiments undertaken to test the theoretical results for a narrow annular gap and for a wide annular gap.

463. The nature of unhomogeneous plastic flow of metal single crystals. E. D. SHCHUKIN, J. V. GORIUNOV, N. V. PERTZOV and V. N. ROZANSKI, *Dokl. Akad. Nauk SSSR*, 1958, **118**, 277—279.

464. The statistical foundation of the equations of the flow through porous media. E. M. MINSKY, *Dokl. Akad. Nauk SSSR*, 1958, **118**, 255—258.

465. On anisotropy of deformation. B. A. BERG, *Prikl. Mat. Mekh.*, 1958, **22**, No. 1. [Russian]

466. A theory of plasticity, taking residual micro-stresses into account. YU. I. KADASHEVICH and V. V. NOVOZHILOV, *Prikl. Mat. Mekh.*, 1958, **22**, No. 1. [Russian]

467. On the general equations of ideal plasticity and the statics of a free-flowing medium. D. D. IVLEV, *Prikl. Mat. Mekh.*, 1958, **22**, No. 1. [Russian]

VOL.
1
1958

468. On the laws of plasticity for a (strain) hardening material. V. D. KLYUSHNIKOV, *Prikl. Mat. Mekh.*, 1958, **22**, No. 1. [Russian]

469. Internal friction and plastic deformation of overstressed micro-regions in a solid. R. I. GARBER and T. T. MOGILNIKOVA, *Dokl. Akad. Nauk SSSR*, 1958, **118**, 479—482.

470. Stress–strain relationships in yarns subjected to rapid impact loading—V. Wave propagation in long textile yarns impacted transversely. J. C. SMITH, F. L. MCCRACKIN and H. F. SCHIEFER, *Text. Res. J.*, 1958, **28**, 288. Textiles Section, Nat. Bur. Stand., Washington 25, D.C., U.S.A. The behaviour of an ideal infinitely long flexible filament after transverse impact is investigated theoretically. Detailed results are presented. D.W.S.

471. A ploughing theory of yarn surface friction. E. J. KALISKI, *Text. Res. J.*, 1958, **28**, 325. Carothers Res. Lab., E.I. du Pont de Nemours & Co., Wilmington, Delaware, U.S.A. A theory of yarn friction involving ploughing has been proposed to explain the dependence of friction on surface roughness. The theory predicts that friction is an inverse function of the radius of the asperities and the square root of the number of asperities. Experimental work on polished and matt surfaces indicates that the theory may apply when boundary friction predominates. D.W.S.

472. A simple derivation of an electroviscous equation. N. STREET, *J. Colloid. Sci.*, 1958, **13**, 288. University of Illinois, U.S.A. A simple derivation of an equation for the electroviscous effect in suspension flow is possible following the approach used by Ball for flow through capillaries. Author

473. Particle motions in sheared suspensions—VII. Internal circulation in fluid droplets (theoretical). W. BARTOK and S. G. MASON, *J. Colloid. Sci.*, 1958, **13**, 293. Phys. Chem. Div., Pulp and Paper Res. Inst. of

Canada and Dept. of Chem., McGill University, Montreal, Canada. Equations are derived for the streamlines inside and outside a viscous fluid sphere suspended at the origin of an infinite body of an immiscible viscous liquid which is undergoing plane hyperbolic deformation using a set of equations for velocity components derived by G. I. TAYLOR. By means of a simple transformation, the same set of equations has been used to determine the streamlines inside and outside a liquid drop undergoing laminar shear flow. Equations are also derived for the time of internal circulation for streamlines close to the surface and near the centre, respectively. Author

474. The dependence of stress distribution on elastic constants. MARGERY CLUTTERBUCK, *Brit. J. Appl. Phys.*, 1958, **9**, 323—329. University College, London. Experimental methods in stress analysis are becoming increasingly important in the design of engineering structures, particularly in the aircraft and associated industries. In this paper the effect of the elastic constants on certain stress distributions is investigated using the photoelastic technique. Similarity in stress distributions is obtained by suitable adjustment of the loads with respect to the Young's moduli of the materials from which the models are made, but no such adjustment is possible to compensate for the differences in their Poisson's ratios. The error introduced by this effect is considered by reference to problems of a particular type, from which some general conclusions are drawn. Author

475. A note on the adhesion of elastic solids. K. L. JOHNSON, *Brit. J. Appl. Phys.*, 1958, **9**, 199—200. Engineering Laboratory, University of Cambridge. A theoretical analysis is made of the stresses acting at the contact surface of two elastic spheres which are assumed to adhere to each other after the force pressing them together has been removed. The stress at the periphery of the contact area is shown to be tensile and infinite, so that adhesion is physically impossible ; the spheres would peel apart. The theoretical results are consistent with the experimental work of BOWDEN and TABOR. Author

Section B

INSTRUMENTS AND TECHNIQUES

476. Physical changes in milk caused by the action of rennet—I. Description of apparatus for measuring rigidity moduli and internal viscosities, tests of reliability and some observations on syneresis. G. W. SCOTT BLAIR and J. BURNETT, *J. Dairy Res.*, 1958, **25**, 297. National Inst. for Res. in Dairying, Shinfield, Reading. Method is modification of that of SAUNDERS and WARD. For creep and recovery, Burgers Body model is applicable. Throughout most of the setting, rate of increase of rigidity is approximately proportional to amount of unset casein. Very remarkable syneresis phenomena, dependent on precise methods of filling gelometer, are reported. G.W.S.B.

477. An apparatus for the viscometry of organic liquids at high temperature. W. G. BURNS, B. MORRIS and R. W. WILKINSON, *J. Sci. Instrum.*, 1958, **35**, 291—293. Atomic Energy Research Establishment, Harwell, Berks. An apparatus suitable for the measurement of the viscosity of organic liquids at temperatures up to 400°C is described. A sealed glass capillary viscometer is used so that oxygen can be excluded and measurement made above the normal boiling-point. The viscometer is immersed in a molten salt mixture contained in a welded tank and is viewed through special windows. A rotation arrangement enables the viscometer to be inverted. Examples are given of its uses on known materials and on the effect of irradiation of *p*-terphenyl. Author

478. "Adsorption errors" in capillary viscosimetry. H. UMSTÄTTER, *Makromol. Chem.*, 1958, **25**, 199—209. [German]

VOL.
1
1958

479. High-temperature viscometer. Z. MENCIK, *Chem. Prumysl*, 1958, **8**, 24—25. [Czech., English summary]

480. Couette viscometer for structural viscosity studies. J. BAARLI and K. GUSSARD, *Rev. Sci. Instrum.*, 1958, **29**, 642—645. Norsk Hydro's Institute for Cancer Research, The Norwegian Radium Hospital, Oslo, Norway. Describes a viscometer suitable for measurements in the centipoise region at rates of shear between 0·167 and 250 sec.$^{-1}$.
H.J.R.

481. Continuous viscosity measurements with an oscillation viscosimeter. I. JAKOB, *Plaste u. Kautschuk*, 1957, **4**, 204. Earlier theoretical considerations on the operation of an oscillation viscosimeter were checked experimentally. The method was satisfactory for Newtonian liquids. The viscosities of high polymer solutions as measured on this instrument were much lower than those obtained on the Hoppler viscometer. These results are discussed and the forces acting on individual macromolecules as a result of shear oscillation which eventually cause them to break up are estimated. (Reduced abstract from *Plastics Tech.*, 1958, **4**, No. 5). [German]

482. A disk rheometer applicable to measuring shortening flow-properties. S. J. LOSKA and E. JASKA, *J. Amer. Oil. Chem. Soc.*, 1957, **34**, 495—500. Pillsbury Mills Inc., Minneapolis, Minnesota. This shortening rheometer will measure the relative viscosities of shortenings under a single shear application, the change in shortening viscosity on repeated working, and the relationship of both these properties as a function of temperature.

483. Rheological behaviour of colloidal systems. J. J. ORTEGA, *Rev. Plasticos*, 1957, **8**, 3, 65. After discussing the usual viscometric methods of determining flow characteristics of Newtonian fluids, the author describes a new rheometer for colloidal systems and gives details of test performed on two asphaltic bitumens. (Abstract in *Plastics Tech.*, 1958, **4**, 496). [Spanish]

484. Mechanical testing of materials in the transition region between steady flow and failure. A. JOBLING and J. E. ROBERTS, *Brit. J. Appl. Phys.*, 1958, **9**, 235—240. Ernest Oppenheimer Laboratory, University of Cambridge. An attempt has been made to overcome some of the defects of the standard methods of mechanical testing of materials. The new method, in which the deformation is brought about by attaching the specimen to a substrate shows that when the final mechanical failure occurs, continuity is preceded by a region of disturbed flow in which the flow lines appear as a pattern of remarkable regularity, the direction of which is not that of maximum shear. Materials such as dry powders, pastes, polymers and vacuum-deposited metals have been studied and show unexpected common features, e.g. fatigue and relaxation of work hardening by vibrations. Author

485. A two-dimensional load-extension tester for fabrics and film. P. B. CHECKLAND, T. H. BULL and E. J. BAKKER, *Text. Res. J.*, 1958, **28**, 399. I.C.I., Fibres Division, Harrogate, England. An apparatus for measuring the load–extension relations for fabrics or films extended simultaneously in two directions at right angles is described. The strain in the homogeneously deformed central portion of the specimen is recorded. D.W.S.

486. High speed tensile testing of fibres. J. W. BALLOU and J. A. ROETLING, *Text. J. Res.*, 1958, **28**, 631. Pioneering Res. Div., Textile Fibres Dept., E.I. du Pont de Nemours and Company, Wilmington, Del., U.S.A. The response of a stress–strain tester to forces arising during the testing of a sample having linear stress–strain characteristics has been investigated theoretically for various rates of straining. The indicated stress–strain relation is shown to deviate increasingly from the true relation as the rate of straining increases. The type of deviation and the reasons for the deviation are discussed in detail. A simple tester designed in the light of the theory is described and some results presented. D.W.S.

487. A method of measuring Poissons ratio for fibres. F. I. FRANK and A. L. RUOFF, *Text. Res. J.*, 1958, **28**, 213. Dept. of Mechanics and Materials, Cornell Univ., Ithaca, N.Y., U.S.A. An apparatus is described for measuring the changes in cross-sectional area which occur during the elongation of textile fibres. The measurements can be made up to rates of elongation of ca. 0·004 in/min. The cross-sectional area of the fibre is determined from measurements of the electrical resistance of a thread of mercury in a capillary tube through which the fibre passes. D.W.S.

488. Gelatinization of starch materials in the farinograph. BEN GROGG and E. F. CALDWELL, *Cereal Chem.*, 1958, **35**, 196—200. The Quaker Oats Company, John Stuart Research Laboratories, Barrington, Ill. Use of a farinograph equipped for operation at 100°C is proposed as a means of evaluating the thermal gelatinization characteristics of starchy materials at higher solids–water ratios than are possible in the amylograph. A wheat starch dough consisting of equal parts of starch and water reached maximum consistency in 2 min when mixed in the farinograph at 100°C. Additions of methyl oleate caused the attainment of

this maximum to be delayed by an interval which was approximately proportional to the amount of ester added. A similar but more striking effect resulted from the addition of oat oil to starch. The gelatinization time of oat flour doughs mixed at 100°C appeared to be proportional to the fat content of the oat flour used. Author

489. A modification of the extensograph for study of the relaxation of externally applied stress in wheat dough. BEN GROGG and DIANE MELMS, *Cereal Chem.*, 1958, **35**, 189—195. The Quaker Oats Company Research Laboratories, Barrington, Ill. A contact switch has been installed on an extensograph which stops the downward movement of the dough hook at a variable but predetermined dough extension. The kymograph continues running after the dough hook stops, resulting in the formation of a relaxation curve. This modification permits the use of the instrument as a "standard" relaxometer to provide direct comparison of results by various investigations. Collaborative studies of stress decay may also be made. A method of treating the experimental data based on the Central Limit Theorem is presented which permits the investigator to study the distribution characteristics of the so-called "spectrum" of Maxwell elements in wheat doughs. Author

490. Estimation of the glass temperature of polyamides. G. BODOR, *Faserforsch. u. Textiltech.*, 1951, **8**, 470—471. An apparatus is described for determining the specific volume of fibres as a function of temperature. A break in the graph of specific volume against temperature gives the glass temperature. (Abstract in *J. Soc. Dy. Col.*, 1958, **74**, 6, 506). [German]

491. The impact test in material testing. W. SPATH, published by A. W. Gentrer, Postfach 688, Stuttgart 1, Germany. In this volume the author covers tough and brittle fracture and the test methods used. The book is divided into three sections : (1) Specifications, test equipment and measured results, (2) Measurements by the author using a new impact tester which measures the maximum load during impact, (3) Conclusions. (Reduced abstract from *Plastics Tech.*, 1958, **4**, No. 5). [German]

492. Dynamic bending strength of the most fragile plastics and other materials. B. BOSSU and P. DUBOIS, *Industr. Plast. Mod.*, 1957, **9**, 44. This study aims chiefly at determining which of the different formulas considered best expresses the resistance to fracture under impact bending of materials that are more resistant to compression than tensile stress (e.g. polymethyl methacrylate, phenoplastics filled with wood flour, phenol-paper laminates, grey cast iron and mineral glass). Tests were carried out at different striker speeds by the Charpy pendulum method ; the apparatus used was equipped with a device for varying the distance between supports. (Abstract in *Plastics Tech.*, 1958, **4**, 496). [French]

493. A new method of examining the mechanical properties and thixotropy of greases under conditions of uniaxial tension. K. I. KLIMOV and B. I. LEONT'EV, *Khim. tekh. Topl. Masel*, 1958, No. 4, 66. [Russian]

VOL.
1
1958

494. Photoelectric flow birefringence instrument of high sensitivity. BRUNO H. ZIMM, *Rev. Sci. Instrum.*, 1958, **29**, 360—367. General Electric Research Laboratory, Schenectady, New York. The paper describes a modification of a conventional concentric cylinder flow birefringence instrument which results in a ten fold increase in the sensitivity and also renders the measurements independent of the visual judgement of the experimenter. The resulting apparatus is fairly complicated but such that the output is linearly dependent on the magnitude of the birefringence. Hence the instrument is particularly suitable for studying small amounts of birefringence and also allows a rational method of correcting for extraneous effects. H.J.R.

495. Gelatin–glycerine gels as materials for the method of optical polarization for studying strain. D. N. OSOKINA, *Kolloidnyi Zh.*, 1957, **19**, 713. Institute of Soil Physics, Moscow. The material is used as a model. Compositions and methods of preparation are discussed. Optical effects should be correlated with strains rather than with stresses. [Russian] G.W.S.B.

496. Rebound relaxation spectra and principle of constant isoelastic curving rates. M. GORDON and B. M. GRIEVESON, *J. Polym. Sci.*, 1958, **29**, 9. A. D. Little Research Institute, Inveresk, Midlothian, Scotland. An apparatus is described for measuring the coefficient of restitution of polymer samples as a function of temperature by observation of the rebound of a steel ball after impact. The validity of the technique is illustrated by results obtained on amorphous and crystalline linear polymers and cross-linked resins. The technique is used for the characterisation of the kinetics of the cross-linking reactions in a number of resins. D.W.S.

497. Tacky adhesion. H. STRASBURGER, *J. Colloid. Sci.*, 1958, **13**, 218. Printing Packaging and Allied Trades Research Association, Leatherhead, Surrey. An instrument, which can split liquid films at speeds from 6×10^{-4} cm sec^{-1} to 6 cm sec^{-1} with electronic recording of the forces involved is described. Results are given for oils and printing inks in films of thickness 0·005 cm to 0·008 cm with viscosities from 1·6 to 68·3 poises. At low speeds the results agree with the earlier work of Stefan. Transition from viscous flow forces to rapid film rupture forces is quantitatively shown; the latter are found to confirm generally the conclusions of Banks and Mills on the function of cavitation in limiting the forces of separation of flat plates joined by a tacky liquid. Author

Section C

METALS AND OTHER SOLIDS

498. The study of the elastic characteristics of the ice covers in the Arctic Zone. E. M. LINKOV, *Vest. Leningr. Univ. ser. fiz. khim.*, 1958, No. 1, 17. [Russian]

499. Viscous and electrical properties of liquid binary alloys and their relation to the structure of the liquid. D. K. BELASHCHENKO, *Zh. fiz. khim.*, 1957, **31**, 2269. [Russian]

500. The influence of the strain rate and recovery on the internal friction in aluminium. CHEN KHUN-I, BAO SEN-KE and L. I. VASILIEV, *Dokl. Akad. Nauk SSSR*, 1958, **118**, 485—487.

501. Stress condition for brittle fracture of mild steel. T. YOKOBORI, H. HAMAMOTO and A. OTSUKA, *Nature, Lond.*, 1958, **181**, 1719—1720. Dept. of Mechanical Engineering, Tohoku University, Sendai, Japan. Tensile tests on mild carbon steel specimens of normal shape and torsion tests on thin-walled hollow cylinders were carried out at liquid-air temperatures to study the stress condition governing brittle fracture and the mechanism of fracture. Disagreement with predictions show that brittle fracture of steel obeys neither the maximum tensile-stress nor the maximum shear-stress condition, and this is attributed to anistropy due to rolling during manufacture, to slip distribution, and to the fact that both tensile- and shear-stress components should be involved at the same time in fracture. W.G.C.

502. Tensile strength of indium. D. S. EPPELSHEIMER and L. J. REITSMA, Jr., *Nature, Lond.*, 1958, **182**, 339—340. Metallurgy Dept., Missouri School of Mines and Metallurgy, Rolla, Missouri, U.S.A. New approximate values for the tensile strength (388 lb/in^2) and percentage elongation (70%) for indium are presented. These values for 99·97% pure indium are suggested should replace previous data obtained from a gold alloy containing 0·29% indium, which are misquoted in the literature as being for indium containing 0·29% impurity. W.G.C.

503. On the friction of inflated rubber tires on ice. C. D. NIVEN, *Canad. J. Phys.*, 1958, **36**, 599—610. Division of Applied Physics, National Research Council, Ottawa, Canada. The friction on ice of small inflated rubber tires was measured, for very slow speeds, on a turntable in a cold room. Thirion's Law was found to hold for sliding friction, but not for rolling friction. Very low coefficients of friction were found at temperatures near 0°C.

504. Strength of glass fibres. N. J. PARRATT, *Nature, Lond.*, 1958, **181**, 1726—1727. Tube Investments Research Laboratories, Hinxton Hall, Cambridge. Fibres of 0·001 in. diameter drawn from soda glass X8 were subjected to tensile and bending tests. The latter gave an elastic failing strain of 5·4%, and this result is very similar to that obtained by Thomas (*Nature, Lond.*, 1958, **181**, 1006 ; *Rheology Abstracts*, 1958, **1**, Abstract No. 238) for tensile tests on E-glass. This consistent difference between the results and the calculated theoretical failing strain for glass is suggested as being due to structural defects.

505. A "super-elastic" single crystal calibration bar. W. A. RACHINGER, *Brit. J. Appl. Phys.*, 1958, **9**, 250—252. Aeronautical Research Laboratories, Dept. of Supply, Box 4331 G.P.O., Melbourne. Elastic strains

VOL.
1
1958

of up to 4 per cent can be attained in a copper–aluminium–nickel alloy in the form of a single crystal suitably heat treated. The high elasticity is due to a reversible martensite transformation induced by stressing. The methods of production and heat treatment of large crystals are described together with details of mechanical properties. The alloy can be machined by conventional methods. Suggestions are made for the development of other super-elastic alloys. Author

Section D

POLYMERS, ELASTOMERS AND VISCOELASTIC MATERIALS

506. An investigation on the process of rupture in the transition region between the elastic and brittle states. V. E. GUL', L. N. TSARSKIĬ and S. A. VIL'NITS, *Kolloidnyĭ Zh.*, 1958, **20**, 318. Moscow Inst. for Technology of Fine-Chemicals. High speed photography of rupture of filler-free vulcanizates from $-57°$ to $+22°$C. Rate of spread of rupture is not monotonically related to temperature. Considerable instability in the transition region between elastic and brittle states. [Russian] G.W.S.B.

507. The dependence of filament tensile strength on the length of the test piece. A. SIPPEL, E-H. HÜTZEN, *Faserforschung*, 1958, **9**, 163—167, 213—217. Research Laboratory, Deutsche Rhodiaceta A.G., Freiburg. Tensile strength data for continuous filament acetate rayon are presented as a function of sample length. The strength of the longer samples is greater than that predicted by Weibull's theory ; reasons for this are proposed. An empirical relation between strength and length is derived. [German] A.S.L.

508. Viscosities intrinseques de solutions de chaines courtes. C. SADRON and P. REMPP, *J. Polym. Sci.*, 1958, **29**, 127. Centre de Recherches sur les Macromolecules, Strasbourg, France. The relation between the intrinsic viscosity and molecular weight for short chain molecules was studied. For polyoxyethyleneglycols and their methyoxyderivatives it was found that an equation of the form $[\eta]=f(M)+KM^a$ was valid over the whole range of molecular weights studied. $f(M)$ depends upon chemical constitution and KM^a depends on the statistical configurations of the molecular chains. [French] D.W.S.

509. A study of graft copolymers—I. Preparation and viscosity behaviour. J. A. MANSON and L. H. CRAGG, *Canad. J. Chem.*, 1958, **36**, 858—868. Dept. of Chemistry, Hamilton College, McMaster University, Hamilton, Ontario, Canada. Graft polymers were prepared by the redox polymerisation of styrene in the presence of oxidised polystyrene or copolymers of styrene and 4-vinylcyclohexene-1. Viscosity measurements suggested that Huggins' k^1, though sensitive to bushy branching, is not much affected by a few linear branches per molecule.

510. The photoelastic behaviour of cross-linked polymers. Z. TUZI and K. KAWATA, *Brit. J. Appl. Phys.*, 1958, **9**, 173—178. Scientific Research Institute, Tokyo, Japan. The photoelastic and mechanical properties of various cross-linked polymers have been studied over a wide range of temperature.

511. Computation of viscosity of viscose solutions. M. N. MARATHE, *J. Sci. Industr. Res.*, 1958, **17B**, 256—259. Staple Fibre Division, The Gwalior Rayon Silk Mfg. (Wvg.) Co. Ltd., Nagda, India. The viscosity of viscose solutions has been correlated with factors such as effective maturing time and temperature, ratio of cellulose to free alkali, and the composition of viscose. The ranges for the different factors studied cover those normally met with in industrial practice. A general equation giving viscosity in terms of all the above factors has been formulated and the conditions under which the equation is applicable have been stated. The equation is only useful in determining the viscosity of viscose solutions under specified process conditions. Author

VOL.
1
195

512. On the viscometry of poly-6-caproamide. F. RYBNIKÁŘ, *J. Polym. Sci.*, 1958, **29**, 519. Research Institute of Rubber and Plastics Technology, Gottwaldov, Czechoslovakia. The influence of molecular weight, temperature and water on the viscosity of dilute solutions of poly-6-caproamide were studied in detail. The results are discussed in terms of the Huggins equation relating the intrinsic and specific viscosities. D.W.S.

513. Influence of crystallinity and of cross-links on the elastic and inelastic behaviour of high polymers. M. BACCAREDDA and E. BUTTA, *Chim. e Industr.*, 1958, **40**, 6—13. [Italian]

514. Polymer solutions—III. Viscosity behaviour of dilute solutions of natural rubber in mixed solvents. S. L. KAPUR and S. GUNDIAH, *Makromol. Chem.*, 1958, **26**, 119—125.

515. Structural effects on the viscosity behaviour of polymer solutions. R. M. JOLIE, *Diss. Abs.*, 1957, **17**, 2841—2842.

516. Effects of capillary shape on flow characteristics and degradation of polymer solutions. H. S. WHITE and H. V. BELCHER, *J. Res. Nat. Bur. Stand.*, 1958, **60**, 215—220. The effects were studied using a tapered capillary, a chamfered capillary and a uniform-bore capillary in a McKee worker consistometer.

517. The glass transition in polymers with the $(CH_2)_n$ group. A. H. WILLBOURN, *Trans. Faraday Soc.*, 1958, **54**, 717—729. Research Dept., I.C.I. Ltd., Plastics Div., Welwyn Garden City, Herts. The meaning of the term " glass transition " and " second order transition " is discussed as applied to polymers showing more than one dynamic mechanical transition. An interpretation is given of the dynamic mechanical behaviour of poly(alkyl methacrylates) linear and branched polymethylenes, polythene, poly(α-olefines), linear polyethers and 6 : 6 nylon. W.H.B.

518. Mechanical properties of wool fibres—I. Creep in the " Hookean " region of wool fibres in water. M. FEUGHELMAN, *J. Text. Inst.*, 1958, **49**, T361. Physics & Eng. Unit, Wool Textile Res. Labs., The Hermitage, 338, Blaxland Road, Ryde, N.S.W., Australia. The creep of wool fibres in water for loads corresponding to the so-called " Hookean " region has been investigated experimentally at temperatures between 20°C and 40°C. A model, based on the Burte–Halsey two state model, has been used to explain the results. D.W.S.

519. Mechanical properties of wool fibres—II. Single fibres at 0% R.H. in the yield region. B. J. RIGBY, *J. Text. Inst.*, 1958, **49**, T379. Physics & Eng. Unit, Wool Textile Res. Labs., The Hermitage, 338, Blaxland Road, Ryde, N.W.S., Australia. The stress–strain relations at constant rate of strain, stress–relaxation relations at constant length and creep relations at constant load for dry wool fibres have been measured and are reported. D.W.S.

520. Some relationships between supermolecular structure and mechanical behaviour of native and chemically modified cotton cellulose. V. W. TRIPP, R. S. ORR, H. M. ZIIFLE and C. M. CONRAD, *Text. Res. J.*, 1958, **28**, 404. Southern Regional Res. Lab., New Orleans, Louisiana, U.S.A. The dependence of strength, elongation at break, stiffness, toughness, elasticity and resilience on such features as molecular chain length, polymolecularity natural cross-linkage, crystallinity, crystal modification, crystallite size, crystal modification, crystallite size, orientation accessibility and chemical modification is discussed. D.W.S.

521. Mechanical properties of cotton fibres and their response to mercerisation. L. REBENFELD, *Text. Res. J.*, 1958, **28**, 462. Textile Research Institute, Princeton, N.J., U.S.A. The changes in fibre extensibility brought about by mercerisation were investigated and found to be related to the degree of fibrillar orientation. The changes in mechanical properties due to mercerisation were found to depend upon the applied tension during the mercerisation. D.W.S.

522. Structure and mechanical properties of vegetable fibres—II. A microextensometer for the automatic recording of load–extension curves for single fibrous cells. L. C. SPARK, G. DARNBOROUGH and R. D. PRESTON, *J. Text. Inst.*, 1958, **49**, T309. Botany Dept., University of Leeds, Leeds, England. The paper describes the performance of a microextensometer for the automatic recording of load–extension curves of single vegetable fibres. The total final load can be varied up to 40 kg/mm² and the extension at full scale deflection can be varied from less than 1% to ca. 100%. Sample load–extension curves of two sizal fibres are presented to show the wide variation of mechanical properties with molecular structure of the fibre wall. Author

523. Preparation and rheological properties of alginate mucilages. R. BOLLIGER and K. MÜNZEL, *Pharm. Acta Helvet.*, 1958, **33**, 141—155. [German]

524. The influence of soya flour on bread doughs—III. The distribution of the papain-inhibiting factor in soya-beans. E. M. LEARMONTH, *J. Sci. Fd. Agric.*, 1958, **9**, 269—273. British Soya Products Ltd., 150/152, Fenchurch Street, London, E.C.3. The papain-inhibiting factor of soya is shown to be concentrated almost entirely in the germ. The cotyledon is without inhibiting power and sometimes has a slight activating effect. A similar distribution of papain-inhibiting factors is shown to exist in other leguminous seeds. Additions of 0·2% to 0·4% of raw soya germ alter the Chopin alveogram of the wheat flour in the same sense as do additions of oxidizing improvers. Author

525. The variability of set in keratin fibres. T. MITCHELL and M. FEUGHELMAN, *Text. Res. J.*, 1958, **28**, 453. Physics and Engr. Unit, Wool Textile Research Labs., The Hermitage, 338, Blaxland Road, N.S.W., Australia. The amount of "permanent" set in a number of keratin fibres was measured, the fibres being strained 40% for 1 hr in distilled water at 100°C and then released slack for 1 hr in water. Variation in the amount of set retained by various keratin fibres was noted. The amount of set appears to correlate strongly with the ability of the particular fibre to supercontract and tends to be dependent on fibre diameter. Author

526. Mechano-chemical systems—II, III. (Expansion-contraction behaviour of hydrolysed poly(methyl acrylate) gel). P. R. CHAUDHURY and S. BASU, *Makromol. Chem.*, 1958, **26**, 67—74, 75—79.

527. Rheological studies on potato starch—II. Effects of metal ions on potato starch. S. TAKAHASHI and Y. YIHARA, *J. Agric. Chem. Soc., Japan*, 1958, **32**, 243—250. [Japanese]

528. Viscosity of cellulose nitrate solutions in solvent and solvent–non-solvent mixtures : dependence of viscosity on rate of shear. A. G. CHITALE, *J. Sci. Industr. Res. India*, B, 1958, **17**, 60—63.

529. The structure and properties of paper—X. Periodic acid oxidation of cellulose fibres and its influence on paper properties. H. G. HIGGINS and A. W. MCKENZIE, *Aust. J. Appl. Sci.*, 1958, **9**, 167—182. A eucalypt α-cellulose pulp was oxidized with periodic acid under various conditions near pH 2 with the objects of obtaining information on the nature of the oxidized cellulose by means of infra-red spectroscopy, and of studying the influence of oxidation on the properties of paper made from the oxidized fibres. The rheological properties of the paper were studied before and after drying. The behaviour of the wet (undried) web under stress showed that oxidation does not give rise to an increase in strength corresponding to the increase in wet strength (i.e. after re-wetting) observed by SCHUR and LEVY (1947) ; a drying stage is necessary for this effect to develop. The properties of the dry paper fluctuate with increasing degree of oxidation. An initial decline in strength is associated with a decline in density, which results from the effect of acid hydrolysis on the fibre surface. When oxidation is sufficiently advanced to open up the

VOL.
1
1958

fibre structure and to destroy the crystallites (changes which are shown by the infra-red spectra and by swelling data), the strength properties rise again to values well in excess of the untreated material. (The sheets are however, less extensible and of a brittle nature and show poor folding properties.) Eventually as the fibre undergoes advanced degradation, by a combination of oxidation and hydrolysis, the strength of the paper again declines. The maximum in strength properties was observed at an oxidant consumption (in the dark) of ca. 0·2 mole HIO_4/glucose residue. [Part of Authors' summary]

530. Reactions of unsaturated fatty alcohols—III. Viscosity and molecular weight studies on some vinyl ether polymers. I. E. GAST, W. J. SCHNEIDER and H. M. TEETER, *J. Amer. Oil Chem. Soc.*, 1957, **34**, 307—310. U.S. Dept. of Agriculture, Peoria, Illinois. It is shown that logarithmic plots of molecular weight vs. intrinsic viscosity gave linear relationships for stearyl, soyabean and linseed polymers. N.W.

531. The effect of urea on the streaming birefringence and viscosity of sodium deoxyribonucleate. A. R. MATHIESON and M. R. PORTER, *J. Chem. Soc.*, 1958, 1298—1300. Univ. College, Ibadan, Nigeria, and British Nylon Spinners Ltd., Pontypool, Mon. Measurements of viscosity and streaming birefringence of DNA from calf thymus glands at 25°C in 0·2*M* sodium chloride and urea are reported. It is suggested that urea makes the DNA molecule more flexible and less asymmetrical. Viscosities were measured in a Couette type apparatus. W.H.B.

532. Molecular size and configuration of cellulose trinitrate in solution. M. M. HUQUE, D. A. I. GORING and S. G. MASON, *Canad. J. Chem.*, 1958, **36**, 952—969. Physical Chemistry Division, Pulp and Paper Research Institute of Canada, and Chemistry Dept., McGill University, Montreal, Que. Viscosity and light scattering measurements on cellulose trinitrate in acetone and ethyl acetate suggested that in the former solvent a random coil configuration was attained, whilst in the latter solvent a configuration transition occurred in the molecular weight range investigated.

533. Stress relaxation during photo-oxidation of peroxide cross-linked rubber. J. R. DUNN, J. SCANLAN and W. F. WATSON, *Trans. Faraday Soc.*, 1958, **54**, 730—739. British Rubber Producers Research Association, Welwyn Garden City, Herts. Stress relaxation under the influence of 365 mμ radiation at 25°C of natural rubber cross-linked with peroxides shows the degradative process is autocatalytic, the presence of oxygen being essential. Stress against time data is examined in the light of the above. W.H.B.

534. Mechanical properties of thin polyethylene film. A. A. ANDERSON and G. L. MORFITT, *Mod. Plast.*, 1958, **35**, 139. An apparatus is described for the determination of stress–strain characteristics of thin films, at elongation rates of 0·03–6 in sec^{-1} and temperatures down to −70°C. The effects of these variables on the stress–strain properties are discussed and it is shown that the ultimate strength and yield stress of the film and its seals increases with decreasing temperature. (Abstract in *Plast. Tech.*, 1958, **4**, 7, 680).

535. On the tensile strength of mixtures of polyethylene and polyisobutylene. R. I. FEL'DMAN and A. K. MIRONOVA, *Kolloidnyi Zh.*, 1957, **19**, 654 (Letter). [Russian]

536. Dynamic viscoelastic properties of low pressure polyethylene. V. A. SOLOV'EV, *Vest. Leningr. Univ. ser. fiz. khim.*, 1958, No. 1, **30**. [Russian]

537. On the viscoelastic properties of crystalline polymers—I. Polytetrafluoroethylene. KAZUO NAGAMATSU, TATSUYA YOSHITOMI and TATSURO TAKEMOTO, *J. Colloid. Sci.*, 1958, **13**, 257. Dept. of Appl. Sci., Faculty of Engineering, Kyushu Univ., Fakuoka, Japan. Ferry's method of reduced variables is applied to the results of stress relaxation measurements at constant length on samples of polytetrafluorethylene. Measurements were made at temperatures from 15°C to 70°C at times ranging from ca. 6 sec to 10 hr. The conditions under which the reduction method can be applied to crystalline polymers are discussed. It is concluded that polytetrafluorethylene has transition points at 19°C and 25°C. These are discussed in terms of the known structure of the polymer. D.W.S.

VOL.
1
1958

538. Responses to environmental changes and an equation of state for nylon yarn. B. H. ECKSTEIN, E. M. OLSON and W. F. AMES, *Text. Res. J.*, 1958, **28**, 701. E. I. du Pont de Nemours and Company, Wilmington, Del., U.S.A. The variation of tension at constant length and length at constant tension have been investigated at constant temperature and varying relative humidities for nylon yarns. "Equations of state" were derived relating these variables and the constants in the equations determined for the samples investigated. D.W.S.

539. The load–deformation curve for nylon. V. LAWS, *J. Text. Inst.*, 1958, **49**, T357. Phys. and Engng Unit, Wool Textile Res. Labs., The Hermitage, 338, Blaxtand Road, Ryde, N.S.W., Australia. The area of contact between a bent nylon bristle and a flat glass plate has been measured at known loads by microscopic examination of the contact making use of two-beam Fizeau interference fringes. The results are interpreted in terms of a simple power law relating the contact area to the applied force. D.W.S.

540. Mechanical properties of nylon—I. Stress relaxation in 6-nylon at different humidities and temperatures. I. MATSUMOTO and K. ISHIKAWA, *J. Soc. Text. Cellulose Ind., Japan*, 1957, **13**, 601—606. The stress–relaxation behaviour of 6-nylon stretched at various degrees of elongation was measured at 8%, 33%, 55% and 75% RH and in water at 25°C, and at 25°, 40° and 55°C at 55% RH and in water. The values of E (stress/strain) obtained at various degrees of elongation, temperatures and RH were plotted against log t (sec). The relaxation curve for nylon under various conditions could be represented approximately by

$$\log t - \log t_0 = 1{\cdot}4 \left\{ \frac{1}{E - E_0} - (E - E_0) \right\}$$

where t is time and E_0, t_0 are constants. The results obtained are as follows (1) At small elongations (2%) the stress/strain relationship is

greatly affected by RH and temp. (2) At low RH high rates of stress relaxation are obtained at 2% and 4%. (3) At high RH (including the tests in water) and at the greater elongations there is a small difference among the rates of stress relaxation. (Abstract from *J. Soc. Dy. Col.*, **74**, 320).

541. Some mechanical properties of mylar and dacron polyester strands at low temperatures. R. P. REED and R. P. MIKESELL, *Rev. Sci. Instrum.*, 1958, **29**, 734—736. National Bureau of Standards, Boulder Laboratories, Boulder, Colorado. Note reporting results of tensile tests at temperatures down to 76°K. Although both materials are polyesters the two different strands exhibit different trends in their mechanical properties as the temperature is lowered; e.g. Dacron strand increased in ultimate strength while Mylar strand's ultimate strength dropped.

542. The effect of the addition of plasticizer on the mechanical properties of compatible polymers of vinyl chloride with vinylidene chloride and of polyvinyl chloride. R. I. FEL'DMAN, A. K. MIRONOVA and S. I. SOKOLOV, *Kolloidnyĭ Zh.*, 1958, **20**, 106. [Russian]

543. Elastoviscous properties of poly(vinyl chlorides) plasticised with dibutyl phthalate, palatinol AH, and dioctyl adipate. J. MAJER and E. NEJEDLY, *Chem. Prumysl*, 1958, **8**, 41—44. [Czech. English summary]

543a. A study of the strength and high-elastic properties of rubber solutions and their vulcanizates at increasing rates of deformation. A. A. TRAPEZNIKOV and T. V. ASSONOVA, *Kolloidnyĭ Zh.*, 1958, **20**, 398. Inst. of Physical Chem., U.S.S.R., Moscow. Ultimate deformations of rubber solutions in decalin (shear rates $14—5\times10^3$ sec^{-1}) were measured and reached 5000%. Elastic deformations at rates up to 1100 sec^{-1} did not exceed 1100%. Vulcanization of 2% solution increased this to 4000—5000%. [Russian] English abstract. G.W.S.B.

544. Plasto-elastic properties of rubber S.K.N.26. A. S. NOVIKOV and F. S. TOLSTUKHINA, *Kolloidnyĭ Zh.*, 1958, **20**, 361. Inst. for Scientific Studies in the Synthetic Rubber Industry, Moscow. Effects of molecular weight (M), fractional composition, fillers and temperature have been investigated by constant stress shearing followed by elastic recovery. For the region of Newtonian flow: $\log \eta = 8{\cdot}54M - 34{\cdot}01$. Elastic modulus falls with increasing polydispersion. Flow of filled stocks obeys Eyring's equation. Fillers do not change activation energy. [Russian] G.W.S.B.

545. Polymer association—IV. Hydrogen bonding and melt viscosities in copolymers of styrene with methacrylic acid. R. LONGWORTH and H. MORAWETZ, *J. Polym. Sci.*, 1958, **29**, 307. Polymer Research Institute, Polytechnic Institute of Brooklyn, Brooklyn, New York, U.S.A. Melt viscosities of styrene and copolymers with 1·5 to 23 mole % methacrylic acid were measured with a parallel plate plastometer. Apparent viscosities were found to drop off sharply with increasing rate of shear in

the range 10^{-4} to 10^{-1} sec^{-1}. Increasing concentration of carboxyl groups leads to pronounced increase in melt viscosity and activation energy of flow. Infra-red spectra of the copolymers were recorded while the samples were subjected to various thermal cycles. Equilibrium in the dimerization of carboxyl groups was established very rapidly above 100°C, but the equilibrium was effectively frozen at lower temperatures. Samples as originally prepared by precipitation from dilute solution were further removed from equilibrium than samples quenched from high temperatures. The results are discussed in terms of the rate process theory of viscosity. Author

546. Compatibility of nitrocellulose and butadiene copolymers—IV. Relaxation behaviour of binary mixtures. S. S. VOYUTSKII, V. I. ALEKSEENKO and L. E. KALININA, *Kolloidnyi Zh.*, 1958, **20**, 20. [Russian]

VOL. 1 1958

547. Changes in specific volume on stretching rubber. A. B. KUSOV, V. I. TROFIMOVA and YU. I. NILOVA, *Kolloidnyi Zh.*, 1957, **19**, 587. [Russian]

548. The dependence of the elasticity of finished rubbers on the molecular weight of the original stock. L. S. PRISS, *Kolloidnyi Zh.*, 1957, **19**, 607. [Russian]

549. The dependence of the viscosity of butadiene-styrene rubbers on their structure. A. S. NOVIKOV and F. S. TOLSTUKHINA, *Kolloidnyi Zh.*, 1957, **19**, 599. [Russian]

550. Dependence of the mechanical properties of gutta-percha on the degree of structurisation and the temperature. T. I. SOGOLOVA, V. I. AIKHODZHAEV and V. A. KARGIN, *Zh. fiz. khim.*, 1957, **31**, 2340. [Russian]

551. The interpretation of stress relaxation measurements made on rubber during ageing. J. SCANLAN and W. F. WATSON, *Trans. Faraday Soc.*, 1958, **54**, 740—750. British Rubber Producers' Research Association, Welwyn Garden City, Herts. Stress relaxation of rubber during ageing is complicated only by bond formation concurrent with degradation and is not significantly influenced by departures from ideal elastic behaviour. The independence of rate of relaxation at constant extension of the initial extension is in accord with a 2-term form for the strain energy. W.H.B.

552. Stress–strain relation of pure-gum rubber vulcanizates in compression and tension. L. A. WOOD, *J. Res. Nat. Bur. Stand.*, 1958, **60**, 193—199. An equation due to MARTIN, ROTH and STICKLER for the stress–strain curve of rubbers in extension is shown to hold also for rubbers in compression. The relevance of the equation to the MOONEY–RIVLIN presentation of the strain energy function is discussed.

Section E

PASTES AND SUSPENSIONS

553. Two- and three-dimensional flow of grains through apertures. R. L. BROWN and J. C. RICHARDS, *Nature, Lond.*, 1958, **182**, 600—601. British Coal Utilisation Research Association, Randalls Road, Leatherhead, Surrey. The rate of discharge of three size grades of dry, sharp sand was measured (1) from wide cylindrical vessels through circular and elliptical orifices, and (2) from wide rectangular vessels through long slits. The results of the three-dimensional flow systems of experiment (1) and of the two-dimensional flow system of experiment (2) could be correlated by considering the number of members of a chain of particles which would obstruct the particular aperture used.

554. Studies of the viscosity and sedimentation of suspensions—IV. Capillary tube viscometry applied to stable suspensions of spherical particles. G. H. HIGGINBOTHAM, D. R. OLIVER and S. G. WARD, *Brit. J. Appl. Phys.*, 1958, **9**, 372—377. Department of Mining, University of Birmingham. A description is given of a series of measurements of the viscosity of stable suspensions of spherical particles in an efflux-type capillary-tube viscometer. It is shown that a form of wall-effect is present in the tube, which causes the apparent viscosity of the suspensions to decrease with decreasing tube-size. The suspensions are shown to behave as though a layer of pure liquid were present along the tube walls, though the layer appears to be only hypothetical in nature. The values of the wall-layer thickness obtained in the present work are used in a brief assessment of a recently-proposed " concentration " theory of wall effect. The final values of the relative viscosity, corrected for wall effect, show no dependence on absolute particle size or particle size-range. All series of results are shown to be governed by a single type of equation, which reduces to that of Einstein at very low values of the volume concentration. Author

555. Stress relaxation in false-bodied suspensions. R. ROSCOE, *Proc. Univ. Durham Phil. Soc.* A, 1958, **13**, 54—58. Physics Department, King's College, Newcastle upon Tyne. An exponential law of relaxation was deduced by SCHWEDOFF from observations on an aqueous gelatine suspension subjected to strain beyond the yield point. This appears to be at variance with later and more extensive measurements on false-bodied suspensions made by HATSCHEK and JANE. Further experiments show that the departure from the exponential law is a spurious effect arising from the use of a measuring apparatus consisting of co-axial cylinders having a wide annular separation. R.R.

556. On the question of developing a kinetic theory of gelation. I. F. EFREMOV and S. V. NERPIN, *Kolloidnyi Zh.*, 1957, **19**, 757 (letter). Leningrad Institute of Technology. Long-range forces between colloidal particles are discussed in terms of potential troughs and an equation is derived for calculating the shear modulus of the gels. [Russian] G.W.S.B.

557. An investigation on the rheological properties of low-moisture peats. M. P. VOLAROVICH and N. I. MALININ, *Kolloidnyĭ Zh.*, 1958, **20**, 311. Dept. of Physics, Moscow Peat Institute. Rheological behaviour of peat, as measured by shear and by compression between parallel plates and in a rotation viscometer, may be described in terms of seven parameters. Comparisons are made between behaviour in the plastic and in the semi-solid states. [Russian, English Abstract] G.W.S.B.

558. Thickening of slurries of gypsum plaster. D. A. POWELL, *Aust. J. Appl. Sci.*, 1958, **9**, 24—35. During the gradual thickening of a slurry of hemihydrate type gypsum plaster increasing amounts of gypsum were detected by thermogravimetric, differential thermal, and X-ray methods. The amount of gypsum found at the completion of the initial set was consistent with the degree of hydration of calcium sulphate hemi-hydrate indicated by a small rise in the temperature of the slurry. The percentage of hemi-hydrate converted to gypsum during the initial setting period depends upon the consistency of the plaster slurry and on the crystal habit of the gypsum formed. The results indicate that the formation of gypsum crystals in a plaster slurry is the main cause of the initial thickening. Author

VOL.
1
1958

559. The influence of electrolytes on the structural-mechanical properties of bentonite suspensions. I. A. USKOV, *Kolloidnyĭ Zh.*, 1957, **19**, 511. [Russian]

560. Rheological curves for ceramic materials as a valuable aid in ceramics technology. S. P. NICHIPORENKO, *Dokl. Akad. Nauk SSSR*, 1958, **118**, 785. [Russian]

561. The orientation of clay particles in the process of deformation of clay pastes. V. S. FADEEVA, *Kolloidnyĭ Zh.*, 1957, **19**, 640. [Russian]

562. Consistency increase caused by adding glycerine to oil-solid systems. H. E. OBERSTAR and C. S. MINER, *Food Tech.*, 1957, **11**, 403—406. The increase in consistency of oil-solid systems when small amounts of glycerine or water are added, has been investigated by use of a plunger rheometer. Some explanation of the phenomenon is given. N.W.

563. Changes in the properties of an asphalt during the blowing operation. L. R. KLEINSCHMIDT and H. R. SNOKE, *J. Res. Nat. Bur. Stand.*, 1958, **60**, 169—172. The relationship between the physical properties and component distribution has been observed at intervals during conversion by air blowing of the asphalt flux to a coating grade asphalt.

564. The dependence of the viscosity of silicate glasses on the temperature. M. KH. KARAPET'YANTS, *Steklo Keramika*, 1958, **15**, 22. [Russian]

565. Viscometry. ANON, *Paint Manuf.*, 1958, **28**, 256. HAWKINS and WAMPNER (*J. Amer. Chem. Soc.*, 1958, **18**, 85. Div. Paint Plastics and Printing Ink Chem., San Francisco Meeting) have attempted to correlate

evaluations of paint brushability by the R.C.I. " Brushability Recorder " with studies of the same paints in the Blackie high shear viscosimeter (*Off. Dig. Fed. Paint Varn. Prod. Cl.*, 1956, **28**, (392), 1037). Criddle and Meader's torsion pendulum surface viscometer (*J. Appl. Phys.*, 1955, **26**, 838) has been used by ARTEL (ref. as HAWKINS and WAMPNER above) in a study of the changes in surface viscosity when solvent evaporates from a thin film of a resin solution. SMALL (*J. Polym. Sci.*, 1958, **28**, (116), 223) has described an instrument for measuring melt viscosities in the range 10^4–10^8 poises using $\geq 0{\cdot}1$ gm material. R.J.C.

566. The preparation, properties and rheological investigation of thixotropic paint systems. O. J. DOHERTY and R. HURD, *J. Oil Col. Chem. Ass.*, 1958, **41**, 42, 77. I.C.I. Ltd., Dyestuffs Division, Blackley, Manchester. The use of a co-axial cylinder viscometer for studying the stress–strain curves of paints at low shear rates and for the measurement of thixotropic recovery is described. These quantities are needed for the evaluation of sagging and flow out. W.H.B.

567. Selective polar adsorption and some rheological phenomena in paint systems. L. DINTENFASS, *J. Oil Col. Chem. Ass.*, 1958, **41**, 125, 149. Taubmans Industries Ltd., St. Peter's, N.S.W., Australia. The effect of polar adsorption on the dispersion and the rheological properties is discussed. Viscosity equations are suggested relating sedimentation volumes and effective (hydrodynamic) volumes of pigments to the relative viscosity of suspensions. Equations are also suggested for rate of thixotropic recovery. W.H.B.

568. A study in paint vehicles—II. L. DINTENFASS, *J. Oil Col. Chem. Ass.*, 1958, **41**, 333—351. Taubmans Industries Ltd., St. Peter's, N.S.W., Australia. A method for estimating the hydrodynamic molecular wt. of resins is described for concentrated solutions. A general equation relating resin concentration temperature and effective polarity is proposed. Data is given for resins and solvents of interest to the paint industry. W.H.B.

569. The influence of the deformation rate on reduction rate of aluminium naphthenate gel and the method of stress–strain oscillographic records. T. G. SHALOPALKINA and A. A. TRAPEZNIKOV, *Dokl. Akad. Nauk SSSR*, 1958, **118**, 994—997.

570. A study of the gel-forming processes of fruit confectionery materials with a cone plastometer. L. S. KUZNETSOV and A. L. SOKOLOVSKII, *Kolloidnyĭ Zh.*, 1957, **19**, 668. Moscow Technical Institute of the Food Industry. The increase in consistency of the pulp is followed by means of the sinking of a cone as the material cools from 100°—20°C. [Russian] G.W.S.B.

571. Spreadability and hardness of butter—I. Development of an instrument for measuring spreadability. V. R. HUEBNER and L. C. THOMSEN, *J. Dairy Sci.*, 1957, **40**, 834—838. Univ. of Wisconsin, Madison,

Wisc. An instrument was developed more sensitive than consumers in detecting differences in the spreadability of butter. The results agreed closely with those obtained from consumer-preference studies.
Author

572. Spreadability and hardness of butter—II. Some factors affecting spreadability and hardness. V. R. HUEBNER and L. C. THOMSEN, *J. Dairy Sci.*, 1957, **40**, 839—846. Univ. of Wisconsin, Madison, Wisc. Temperature of the cream after pasteurization and that of the butter during storage and the printing procedure had the greatest influence on hardness and spreadability of butter. Storing cream at above 48°F after pasteurization and butter below 25°F improved the body of butter.
Author

VOL.
1
1958

573. Flow properties of starch powders and mixtures. D. J. CRAIK, *J. Pharm., Lond.*, 1958, **10**, 73—79.

574. Rheological properties of dark chocolate masses. R. HEISS and W. BARTUSCH, *Fette u. Seif., Anstrichmittel*, 1956, **58**, 868—875 (abstracted in *Food Tech.* **12**, January, 1958). Technological factors which influence the flow properties of chocolate mass are distribution of particle size, H_2O content, duration and type of conching procedure, fat content, addition of lecithin, ageing of the mass, and temperature and degree of seeding. Recent experimental work illustrating the effect of these factors on viscosity measurements in chocolate mass are reported. [German]
N.W.

Section F

LIQUIDS

575. Transient fluid motions in saturated porous media. J. R. PHILIP, *Aust. J. Phys.*, 1957, **10**, 43—53. The transition from rest to steady motion on the sudden application of a potential gradient to the fluid contained in a saturated porous medium is investigated. An approximate analysis gives the result that the time of the effective establishment of the steady motion is proportional to the permeability and inversely proportional to the kinematic viscosity. Two exact solutions (one of them new) for simple cases suggest that the approximate analysis is remarkably accurate. An analogy between this problem and one in heat conduction makes the relevant results in that field immediately applicable here. The analysis is extended to motion with the time variation of the applied potential gradient quite general. Certain properties of the motion when the potential varies periodically are determined, and the simple harmonic case is studied in some detail. It is found that the error in using Darcy's law (which neglects the transient phase) will usually be unimportant for the case of a suddenly applied potential gradient. However, significant deviations from Darcy's law may occur when the applied potential gradient is periodic, even for systems of quite

low frequency. The equations derived from the approximate analysis may be regarded as generalizations of Darcy's law which take into account time variation of the applied potential gradient. Author

576. Investigation of liquid system by the deviation from additivity of their viscosity logarithms. A. Ya. Deich, *Zh. fiz. khim.*, 1957, **31**, 2336. [Russian]

577. The boundary conditions governing fluid motions in porous media. J. R. Philip, *Aust. J. Phys.*, 1957, **10**, 587. The author points out that in his paper (*Aust. J. Phys.*, 1957, **10**, 43—53) equation 2.8 and the thermal analogy presented hold exactly for axial flow in tubes of general cross-section, but are approximations when applied to more general media. E.R.B.

578. The development of sea waves from their initiation to the phase of maximum steepness. V. V. Shooleikin, *Dokl. Akad. Nauk SSSR*, 1958, **118**, 472—475.

579. Non-Newtonian viscosity of poly-γ-benzyl-*L*-glutamate solutions. Jen. Tsi Yang, *J. Amer. Chem. Soc.*, 1958, **80**, 1783, 1788. Research and Development Division, American Viscose Corporation. The viscosity of solutions of poly-γ-benzyl-*L*-glutamate in *m*-cresol and dichloracetic acid was measured over a range of shear stresses up to 10^5 dynes cm^{-2}. Non-Newtonian behaviour above a critical stress was markedly affected by configuration. At the highest stress attainable the intrinsic viscosity was less than 1/10 of its value at rest when in the rod configuration, whereas in coil form it retained more than 50% of its rest viscosity.

580. Microwave absorption and molecular structure in liquids—XXI. Relaxation times viscosities and molecular shapes of substituted pyridines, quinolines and naphthalenes. Robert W. Rampolla and Ch. P. Smyth, *J. Amer. Chem. Soc.*, 1958, **80**, 1057, 1061. Frick Chemical Laboratory, Princeton University, U.S.A. Dielectric constant and loss measurements at wavelengths from 1·25 to 300 m at 20°, 40° and 60°C in pure liquid state and on 1-nitro naphthalene in dilute benzene solution indicate that a change in the direction of the dipolar vector for similarly shaped non-spherical molecules has a marked effect on the relaxation time but not on viscosity. A rough proportionality exists between relaxation time and viscosity for molecules of not too different size and shape provided their dipole vector directions do not vary appreciably. W.H.B.

581. Anomalies de la birefringence d'ecoulement de certaines solutions trés dilueés d'acide desoxyribonucléiqué. M. Joly, *J. Polym. Sci.*, 1958, **29**, 77. Institut Pasteur, Paris, France. Anomalies in the streaming birefringence of very dilute solutions of sodium desoxyribonucleate solutions have been observed. The anomalities are discussed in some detail and compared with other known properties of these solutions. [French] D.W.S.

Section G

GENERAL

582. Rheological classification. ANON, *Paint Manuf.*, 1958, **28**, 236. A report of the system of L. Dintenfass for dispersions of pigments in vehicles is given. Seven types are distinguished :—Newtonian–Newtonian, dilatant–Newtonian, thixotropic–dilatant, etc. The system has been fully published in *J. Appl. Chem.* R.J.C.

583. The flow of blood in relation to the vessel wall. G. W. SCOTT BLAIR, *Nature, Lond.*, 1958, **182**, 90—91. University of Reading, Berks. A brief report of a meeting held at the Charing Cross Hospital Medical School, London, to discuss haemorheology. Contributors included Profs. K. WEISSENBERG and M. H. KNISELEY, and Drs. A. L. COPLEY, F. K. BELLER, N. C. LAKE, G. W. SCOTT BLAIR and P. H. STAPLE.

VOL.
1
1958

584. The effect of ferric oxide on the viscosity of enamels containing, or devoid of, boron. K. P. AZARON and S. B. GRECHANOVA, *Dokl. Akad. Nauk SSSR*, 1958, **118**, 348—350.

585. The centripetal-pump effect in a vacuum pump. M. REINER, *Proc. Roy. Soc.* A, 1958, **247**, 152—167. Israel Institute of Technology, Haifa. An instrument is described which works as a centripetal vacuum pump. It consists of two co-axial circular plates, one stationary (the stator) with an opening in the centre, the other rotating (the rotor) with constant speed and free to move along the axis of rotation. Experiments show that (1) the rotor is kept at a distance D from the stator which increases with the speed of rotation of the rotor, and (2) a pressure difference $p_0 - p_R > 0$ is produced, where p_0 is the pressure at the opening in the stator and p_R is the pressure at the rim, which varies with the angular velocity of the rotor. These two phenomena can be accounted for theoretically on the assumption that air is " non-Newtonian ". J.R.J.

586. Surface conductance and thixotropy. N. STREET, *Aust. J. Chem.*, 1957, **10**, 207—208. The calculation of the zeta-potential of more concentrated suspensions than is possible by the microelectrophoretic method is possible using measured surface conductances. The application of the method to some eixsting results for bentonite suspensions in potassium bromide is described. E.R.B.

587. Rheology and viscometry. S. LE SOTA, *Paint and Varnish Prod.*, 1957, **47**, 60. National Lead Co., Philadelphia. The author gives a review of some of the fundamental concepts and definitions of rheology in outline form as an introduction to viscometry and continuous recording viscometry. A viscometer directory has been included to illustrate and describe the various types of viscometers, their units, range and principle of mechanism. The 34 figures illustrate the broad range of information provided. Author

LIST OF JOURNALS COVERED FOR RHEOLOGY ABSTRACTS

Analyt. Chem.
Ann. N.Y. Acad. Sci.
Appl. Sci. Res., Gravenhage.
Arch. Mech. Stosowanej.
A.S.T.M. Bull.
Aust. J. Appl. Sci.
Aust. J. Phys.

Bitumen, Teere, Asphalte u. Peche
Brit. Chem. Engng.
Brit. J. Appl. Phys.
Brit. Plast.
Brot. u. Gebäck.
Bull. Acad. Sci. U.R.S.S.
Bull. Amer. Ceram. Soc.

Cah. Groupe Fr. Rheol.
Canad. J. Chem.
Canad. J. Phys.
Cereal Chem.
Chem. Rev.
Chim. et Industr.
Clays and Clay Min.
Clay Min. Bull.
Colloid J., Veronezh
Coll. Trav. Chim. Tchécosl.
C.R. Acad. Sci.

Dairy Ind.
Diss. Abs.
Dokl. Akad. Nauk SSSR
DSIR Contents List

Engineer, Lond.
Engineering, Lond.
Erdöl u. Kohle

Faserforschung
Fluid Handling
Food Tech.
Fuel

Glass Ind.
Glastech. Ber.
Glyce ine News

Helv. Chim. Acta.
Helv. Phys. Acta.

Ind. Eng. Chem.
Indust. Chem.
Instrum. Pract.

J. Amer. Ceram. Soc.
J. Amer. Chem. Soc.
J. Amer. Concr. Inst.
J. Amer. Leath. Chem. Ass.
J. Amer. Oil Chem. Soc.
J. Appl. Mech.
J. Appl. Phys.
J. Ceram. Ass. Japan
J. Chem. Educ.
J. Chem. Phys.
J. Chem. Soc.
J. Chim. Phys.
J. Colloid Sci.
J. Dairy Res.
J. Dairy Sci.
J. Fluid Mech.
J. Franklin Inst.
J. Imp. Coll. Chem. Engng. Soc.
J. Inst. Fuel
J. Inst. Met.
J. Inst. Petrol
J. Mech. Phys. Solids
J. Oil Col. Chem. Ass.
J. Phys. Chem.
J. Polym. Sci.
J. Rat. Mech. Anal.
J. Res. Nat. Bur. Stand.
J. Sci. Fd. Agric.
J. Sci. Industr. Res.
J. Sci. Instrum.
J. Soc. Dy. Col.
J. Soc. Glass Tech.
J. Soc. Leath. Tr. Chem.
J. Soil Sci.
J. Text. Inst.

Kolloidnyĭ Zh.
Kolloidzschr.
Kunststoffe

Lab. Practice
Lubric. Engng.

Mod. Plast.

Nature, Lond.
Neftyanoe Khoz.
NLGI Spokesman
Nuovo Cim.

Oil Ind., Moscow

Paint Manuf.
Paint Tech.
Petrol Engr.
Petrol Process.
Petrol Refin.
Petroleum, Lond.
Phil. Mag.
Phil. Trans.
Phys. Rev.
Plastics, Lond.
Plastics Tech.
Proc. Camb. Phil. Soc.
Proc. Phys. Soc. Lond.
Proc. Roy. Soc.
Proc. Soil Sci. Soc. Amer.
Process Control

Quart. Appl. Math.

LIST OF JOURNALS COVERED FOR RHEOLOGY ABSTRACTS

Research, Lond.
Rev. de l'Inst. franç. du pétrole
Rev. Mat. Constr.
Rev. Mod. Phys.
Rev. Sci. Instrum.
Rheol. Acta
Rubb. Chem. Technol.

Sci. Lubric.
Silicates Industr.
Soil Sci.
Sov. Phys. JETP
S.P.E.J.
Svensk Pappers Tidning

Tappi

Text. Res. J.
Trans. Brit. Ceram. Soc.
Trans. Faraday Soc.
Trans. Plast. Inst., Lond.
Trans. Soc. Rheol.

Verres et Réfr.

Wire Ind.
Wire Prodn.
Wire and Wire Prodn.

Zement-Kalk-Gips

VOL.
1
1958

Summaries of papers read at a Symposium on the " Rheology of Road Materials ", organised by the British Society of Rheology in London on 24 *October*, 1958.

Test methods for examining the flow of concrete during and after compaction

By P. J. F. WRIGHT (Road Research Laboratory, Department of Scientific and Industrial Research)

The two properties of fresh concrete which determine its suitability for a particular use are the ease with which it can be compacted without serious segregation occurring and the ease with which the partially or fully compacted mass can accommodate itself to the required shape, which may involve flowing around and between reinforcing bars. Both processes are frequently performed by applying vibration ; they take place simultaneously but it is convenient to consider them separately. Most tests are designed to assess one or the other.

Of tests to assess the ease of compaction of concrete the most widely used in Great Britain is the Compacting Factor test originally developed at the Building Research Station and now incorporated in British Standard 1881. This test measures the degree of compaction achieved when a sample of concrete is allowed to fall through a fixed height. Although this test has been widely used it employs a very different method of compaction from that used in the field and in general it does not achieve full compaction of the sample. For these reasons it does not always provide a reliable indication of the ease of obtaining full compaction by vibration and more recent work has been directed to this more specific requirement.

STEWART devised a method later used by VENKATARAMAIAH for determining the amount of work used in compacting a sample of concrete in which the sample is compacted in a mould attached to a specially built resonant vibrating table. The power drawn by the vibrator is measured by a wattmeter, the value falling to a minimum when the concrete reaches the fully compacted state. This apparatus involves the use of extensive electronic equipment which makes it unsuitable for general use but it provides a sensitive technique capable of providing valuable data for designing concrete mixes.

Working on the specific problem of compaction in concrete roads the Road Research Laboratory has recently developed an apparatus in which a sample is compacted by vibration applied to the top surface. The characteristics of the vibration approximate to those of typical equipment for vibrating concrete roads and the vibration is normally maintained for a period of 40 sec. The degree of compaction obtained can then be measured and it is usual to repeat the test with several water contents until a point is reached at which full compaction is just achieved. This

apparatus has provided very useful data in connection with designing mixes for road construction and it is hoped to produce a series of data for general use in designing this type of mix.

A number of tests for assessing the ability of a mass of concrete to flow have been devised, several being based on the original Powers Remoulding Test developed in the U.S.A. The most widely used is the Swedish Vebe meter which requires a standard slump cone to be filled on a small vibrating table. After removal of the metal cone the concrete is vibrated until it occupies a cylindrical form in a mould of slightly greater diameter than the base of the slump cone. The time taken to reach this condition is measured and a transparent plate resting on the surface of the concrete helps in determining the end point. There is, however, an element of judgement in this assessment, which results in different operators giving somewhat different figures. Nevertheless, the test is a practical one (provided a 3-phase electricity supply is available) and appears to be sensitive to small changes in mix proportions.

VOL.
1
1958

More fundamental work on the shear strength, elasticity and viscosity of fresh compacted concrete has been carried out at a number of laboratories, notably at the Swedish Cement and Concrete Research Institute. In an apparatus used there a torsional oscillation is initiated in a vertical shaft fixed at the upper end, coupled to the concrete by means of vanes at the lower end and provided with a system of weights to serve as a flywheel. The damping of the oscillations by the internal friction of the concrete is recorded electronically and the concrete can be subjected to vibration if desired. The apparatus has been used to show how mixes can be modified to reduce any tendency for segregation to occur under prolonged vibration and the investigation shows promise of contributing to the understanding of the behaviour of fresh concrete although in its present form the apparatus would be unsuitable for use as a control test.

Rheological tests in the control of bituminous mixtures

By D. C. Broome (The Limmer and Trinidad Lake Asphalt Company Ltd.)

Simple rheological tests have been used in the bitumen industry since time immemorial and empirical tests are standardised by the Institute of Petroleum and the British Standards Institution. These largely revolve around the needle Penetration Test and the Ring and Ball Softening Point test. The Ductility test is also standardised, although the value of this is still in doubt. Temperature susceptibility may be measured in a variety of ways and, in particular, by the Penetration Index scheme, and by the Fraass Brittle Point test.

Some advantage may be obtained by study of the extent to which a bitumen may deviate from Newtonian flow, whilst there would appear to be some potential merit in a scheme to relate the Penetration and the

Ring and Ball Softening Point with the time of loading. In this way a " stiffness modulus " may be obtained, but the industry has so far been loath to adopt this scheme and to apply it to practical problems of control.

The only rheological test at present adopted as standard by the B.S.I. for bituminous mixtures in the form in which they are generally used on the road, roof or floor, etc., is the so-called Hardness Number test, adapted from the needle Penetration test for bitumens. This is used very extensively as the main factory control test for mastic asphalt. A corresponding test for rolled asphalt mixtures has not proved very practical for control purposes. The problem is often complicated in practice, especially on floors, by the application of loads through small bearing areas.

Mechanical stability tests are now being used in the design and control of asphalt mixtures, especially for aerodrome surfacing. The commonest of these is the American Marshall Stability Value, which is used in conjunction with tests for " flow ", and for void content. Practical stability tests on the completed work are also being employed, with particular reference to checking the degree of compaction of the asphalt.

Research has been carried out on sundry other rheological problems, especially regarding the behaviour of asphalt mixtures at sub-zero temperatures, but this has not yet been applied practically in either the design or control of mixtures.

It is considered that rheological tests play an important part in the design and control of bituminous mixtures, and an increasing interest in these is being taken both by manufacturers and by users. The industry continues to rely almost entirely on purely empirical tests, but the value of fundamental research is slowly being appreciated.

The use of mechanical tests for bituminous surfacings

By A. Please (Road Research Laboratory, Department of Scientific and Industrial Research)

Bituminous surfacings for roads must (1) be durable, (2) be stable and (3) have a good resistance to skidding. Weather and traffic effect profound changes in the structure of " open-textured " surfacings and for this reason measurements of mechanical properties are normally made on dense compositions with a small percentage of voids.

Mechanical testing has been used at the Laboratory to design mixtures, i.e., to determine the most suitable proportions of given constituent materials, to compare their resistance to plastic flow at high road temperatures and their brittle properties at low road temperatures. A particular use has been to examine the effect on these properties brought about by modifications of the binder, or type of filler and fines. Structural changes and hardening of the binder in the surfacings have been

followed with the aid of mechanical tests and some contribution made to the knowledge of basic principles of flow of bituminous materials in simple conditions of stress. Examples of these uses are discussed in detail.

(1) *Design*

An important part of design is the selection of the binder content. Too much binder may give deformation or an unduly smooth surface, too little may give pervious surfacings liable to disintegration. Tensile or bending tests have been used to determine an " optimum " binder content, for which the steady creep rate is a minimum. This optimum binder content has been used to give the estimated range of binder contents to be employed for compositions in full-scale experiments. The binder content that proves most successful in these experiments has been shown to depend on the traffic and temperature.

VOL.
1
1958

The design of dense tar surfacing using these tests has been described proceeding from filler/binder to sand/filler/binder mixtures, with the Wheel-tracking test being made on the complete mixture containing stone.

(2) *Resistance to deformation*

The flow behaviour of bituminous compositions has been examined in conditions of steady load, constant rate-of-strain and dynamic loading. The complexity of their flow behaviour is shown by these tests, making some method of simulative testing desirable if a useful assessment is to be made of the practical stability of these surfacings. Simulative tests such as the Wheel-tracking Test with a small Road Machine and tests in which a constant rate of strain is imposed have been used to compare the stability of compositions conforming to specifications. The Road Machine has also been used to determine the dependence of stability on temperature. Increasing the viscosity of the binder increases greatly the resistance to deformation in practice and this effect has been used to assess the utility of some empirical tests.

(3) *Flexibility and brittleness*

Bituminous surfacings can fail by cracking either on the macro or on the micro scale. Bitumen and tar have approximately equal tensile breaking strengths. Decreasing the cross-sectional area of the specimen of binder tested greatly increases the tensile breaking strength. The addition of a fine mineral filler increases the breaking strength with, however, a simultaneous increase in the viscosity of the mixture so that there is little or no change in its Fraass brittle temperature. An example is given of the cracking of a mastic asphalt laid on steel bridge decking. In winter the time-dependent elastic modulus of mastic asphalt is sufficiently high to give a substantial reduction in the strain undergone by a steel bridge deck under dynamic loading by traffic.

Normal binders can be modified by the addition of polymers to give highly elastic fluids. The extent to which such modified binders can be used to increase the flexibility of bituminous mixtures is being studied with a simple beam test made on sand/filler/binder systems to compare their breaking strength as a function of temperature. There is a maximum value of the breaking load which occurs at a temperature where there is a transition from brittle to dilatant fracture. The maximum breaking load is substantially independent of the type of binder tested although dependent on the grading of the aggregate. Rubberised bitumen makes mixed materials more resistant to deformation and at the same time less brittle.

(4) *Ageing and weathering*

Mixed materials change their mechanical properties by weathering and ageing. A simple beam test measures these changes in specimens either prepared in the Laboratory or taken from the road. Rolled asphalts harden after laying and there is a difference in behaviour of beams cut from the road at different points.

(5) *Flow in simple conditions of stress*

When tested in simple tension or in simple shear, bituminous materials deform quickly at first, the rate settling down to some steady value and finally increasing to the point where progressive cracking occurs. The steady rate is a power function of the applied stress. Bituminous materials exhibit dilatancy when tested in simple shear or tension and a coefficient of volume viscosity has been defined. The relative increase in viscosity of filler/binder systems using many types of filler at different concentrations depends primarily on the purely physical parameters, the relative volume concentration of filler and the mean pore radius of the compacted filler.

The rheology of bituminous road mixtures

By R. N. J. Saal (Koninklijke/Shell-Laboratorium, Amsterdam, N.V. De Bataafsche Petroleum Maatschappij)

(1) The rheology of bituminous road materials is discussed particularly in relation to the conditions of stress, loading time and temperature which are critical for the performance of the road. These critical conditions are :

(*a*) Suitable viscosity of the bitumen at mixing temperatures ;

(*b*) Sufficiently high stiffness of the mix at maximum road temperatures to keep deformations of the carpet within acceptable limits ;

(*c*) Sufficiently low stiffness of the mix at minimum road temperatures to avoid crack formation.

(2) The rheological properties of bituminous road mixtures depend upon those of binder and aggregate.

The bitumen binder is a visco-elastic material of a relatively simple nature. In constant-loading experiments at various temperatures the stress–strain ratio (the "stiffness modulus") of a given bitumen is found to be to a good approximation a function of a product of the loading time and a function of temperature, as demonstrated in Fig. 1.

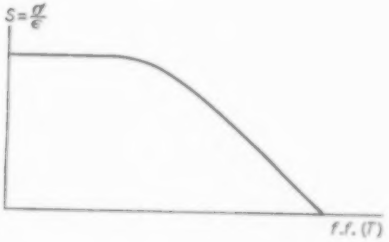

FIG. 1. Stiffness of bitumen as a function of time and temperature.

The maximum value of the stiffness, which in principle is a generalized Young modulus, amounts to 3×10^{10} dyn/cm^2=3×10^4 kg/cm^2=40×10^4 lb/in^2.

The aggregate consists of particles of a solid with a Young modulus about 10^2 times the maximum for bitumen. The aggregate as a whole is a plastic material with a yield stress depending linearly upon isotropic pressure, i.e. upon the average of the three principal stresses, and with a differential viscosity equal to zero (Fig. 2). The increase in yield stress with pressure is governed by the coefficient of friction between the aggregate particles.

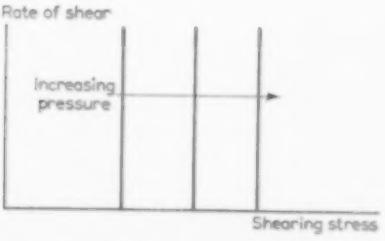

FIG. 2. Rheological nature of aggregate.

The rheological properties of mixtures depend upon the deformation applied.

(*a*) For small deformations (up to 1%) these properties can again be expressed by a generalized Young modulus, which is a single-valued function of the modulus of the aggregate, of that of the binder at equal temperature and time of loading, of the concentration of the binder and of that of the voids.

(*b*) For large deformations (>2%) two cases have to be distinguished :

(i) Mixtures containing voids. At large deformations the friction between the aggregate particles becomes such that the plastic nature of the aggregate predominates ; the coefficient of friction is slightly lower than that of the pure aggregate. The differential viscosity is considerable and not constant (Fig. 3).

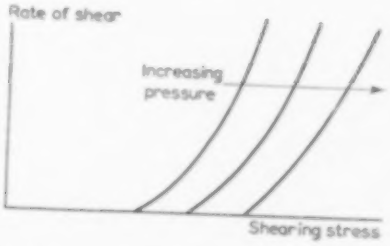

FIG. 3. Rheological nature of mixtures with voids at large deformations.

(ii) Mixtures without voids. Here there is no friction between the aggregate particles, so that the rheological properties are analogous to those at small deformations.

(3) To account for the phenomenon of crack formation the tensile strength of mixtures has also to be considered. This strength amounts in most cases to 10–25 kg/cm^2=150–350 lb/in^2.

For a complete understanding of the behaviour of the carpet the mechanical properties of the other layers of the road construction should also be known. In the present discussion it suffices to say that for normal road constructions moving traffic gives rise to elastic relative elongations of the order of 10^{-4}, decelerating traffic to elastic shear up to the order of 10^{-1} and standing traffic to viscous deformations up to 10^{-1}.

(4) The composition of mixtures satisfying the three limiting conditions mentioned under 1 depends among other things upon weight, intensity and nature of traffic, maximum and minimum atmospheric temperature and strength of the underlying construction. Furthermore, some hardening of the bitumen due to oxidation during the life of the road has to be taken into account.

As an example, " average " conditions and asphaltic concrete (which contains some voids) are taken and good agreement between a design based upon the above considerations and practical experience is demonstrated.

An apparatus for the measurement of breaking strength and stiffness of bitumen at loading times of about 1 millisecond

By J. PARKIN and R. C. ROBSON (Shell Research, Limited,

Thornton Research Centre)

VOL.
1
1958

An apparatus has been developed for the measurement of the breaking strength and stiffness of bitumen at loading times of about 1 msec. The need for this apparatus arose from a study of the phenomenon of fretting of road surfaces, but it will also be useful in other connections.

In operation the apparatus produces the extension of a cylindrical specimen of bitumen so that the bitumen is fractured in a time of about 1 msec, and provides measurements of the stresses, strains and times involved.

The cylindrical specimen 0·5 cm long and 0·3 cm in diameter is formed with one end attached to a tip on a force transducer which is fixed in place at one end of a metal block, the other end being attached to a tip on a cylindrical yoke which is free to slide lengthwise along a cylindrical hole in the block, and which carries at its upper end the core of a movement transducer. Part of the metal block is cut away and lined with insulating material and a perspex cover is fitted so that the specimen is enclosed within an insulated chamber. The tip of the yoke is made from insulating material to cut down heat transfer from the upper part of the block and the specimen may be cooled as desired by blowing cold air into the chamber, the air escaping through holes drilled in the block around the force transducer. The specimen is first formed within a thin-walled copper cylinder which carries a heating coil. When the specimen is sufficiently cooled a suitable current is passed through the heating coil to heat the cylinder and the surface of the bitumen, when the cylinder can be slid along the tip carried by the yoke, thus exposing the bitumen specimen.

Extension of the specimen is obtained by allowing a projecting arm carried by a rotating flywheel to strike a steel inset carried by the yoke. A piece of lead on the arm eliminates bouncing and ensures that the yoke and flywheel move together after contact, and the yoke moves with a substantially constant velocity. The velocity may be varied by changing the angular velocity of the flywheel.

The transducers are used in conjunction with standard frequency modulation equipment, the force transducer acting as a variable capacitance and the movement transducer as a variable inductance. An oscilloscope trace representing the relation between force and movement,

and including timing marks obtained from a crystal oscillator, is obtained and photographed. With suitable calibration and after correction to allow for the stretching of the yoke, the trace can be analysed to give the extension of the bitumen specimen and the force developed at any time up to the time of fracture. From these and the dimensions of the specimen the stresses and strains and hence the stiffnesses are readily obtained, and the breaking strength is obtained from the maximum force registered.

It has been found that for a given time of loading the repeatability of the stiffness is good, and furthermore the stiffness does not appear to vary with the stress. The repeatability of the breaking strength is not as good. It has been found that the inclusion of small air bubbles in the specimens leads to rather low breaking strengths, and differences are found in the appearances of the fracture surfaces. When the results from specimens containing air bubbles are not included the repeatability of the breaking strength is much better, although some variation is still found.

Summaries of papers to be read at a Symposium on "Flow, Fatigue and Failure" to be held by the British Society of Rheology in Leeds on 8–9 January, 1959.

VOL.
1
1958

Kinematic features of the brittle fracture phenomenon

By J. LEEUWERIK (T.N.O., Delft)

Morphological studies of fracture surfaces of different materials lead to the conclusion that the nucleation of the fracture process is influenced by the microstructure of the material. In some cases the further development of the process is affected as well. The course of the fracture process may be reconstructed with the aid of fracture traces which are found on fracture surfaces.

The primary fracture front is nucleated in the primary fracture source. Initially this front forms a smooth surface. In the field of stress concentration of the primary front other secondary fracture sources may come into existence and develop secondary fracture fronts. By intersection of these fronts fracture traces are formed, the form of which resembles hyperbolae and parabolae. The velocity of fracture propagation increases and finally a rough surface structure is formed.

With micrographs it will be illustrated that various materials show this simplified fracture pattern. The light- and the electronmicroscope were used with high magnification to study more in detail the surface structure of the different regions. Moreover surface roughness measurements were performed. Special attention was paid to the geometry of fracture sources and hyperbolae. Some supplementary experiments showed the effect of a 90°-rotation of the largest principal stress upon the critical condition of inhomogeneities. A rough estimation could be made of the number of dangerous inhomogeneities per cm^3.

Fatigue surface patterns on isotropic substances

By P. U. A. GROSSMAN *(Ernest Oppenheimer Laboratory, University of Cambridge)

Materials of widely differing rheological properties show a marked similarity in the appearance of surface disturbances preceding failure. The geometry of these disturbances depends on the applied mechanical treatment and on the geometry of the material's inhomogeneity and anisotropy. The investigation described here aims at determining the influence of the mechanical action alone and deals therefore with materials that are isotropic and homogeneous within the measured dimensions. It takes a purely phenomenological approach and does not attempt to interpret the observed effects in terms of the structure of the material.

---

*Address at time of conference : Division of Forest Products, C.S.I.R.O., Melbourne, Australia.

The tested specimen is strained by WEISSENBERG'S[1] method employing a flexible boundary member which transmits to it a uniform strain by contact over a main plane of imposed strain. The advantages and applications of this method have been discussed by JOBLING and ROBERTS [2, 3] who also describe flow patterns observed on the surfaces of powders, pastes, and films. This paper carries the investigation further, giving more detailed measurements under a wider variety of strains. It is however confined to powders which are a convenient test material for the early stages of the investigation.

A thin layer of powder adhering to a stretched rubber sheet was subjected to cycles of strain whose amplitudes, relative phases and frequencies were controlled in the two dimensions of the contact plane. The instrument that provides such controlled strain was described elsewhere.[4] At sufficiently large amplitudes a pattern of ridges developed on the surface of the powder. The shape and height of these ridges, the distances between neighbouring parallel ridges and their directions were measured.

The growth of the ridges and their shape were observed from the shadow of a straight edge illuminated at an oblique angle. As the powder is vibrated ridges rise from the flat surface, their height increasing gradually and approaching a limiting value. Incipient cracks on the ridge tops become visible early in the process ; they become wider and deeper and join into continuous splits. The walls of the ridges are steep and rise sharply from the flat level.

The distance between neighbouring ridges is linearly related to the powder thickness, i.e., to the distance of the observed surface from the surface of strain application. The coefficients of this relation did not vary strongly from one powder to another. The regular spacing of the ridges suggests a wave mechanism for propagation of the disturbances through the material.

The preferential directions of the fatigue ridges as well as the degree of preference or randomness can be varied by suitable test conditions. Since the directions of the ridges are the ones in which failure is most likely to occur, knowledge of their dependence on the applied mechanical actions and other conditions is of great interest. It was found that the prime factor determining preferential directions is the ratio of the two principal components of strain in the plane of the surface. When one of these components is zero, in uniaxial strain, the fatigue pattern consists of one set of parallel ridges at right angles to the non-zero strain component.

When the ratio of the two strain components is constant and positive, the fatigue patterns consist essentially of two sets of parallel ridges each extending along one of the principal directions. Their relative intensity and the randomness depend on the value of the ratio.

When the ratio of the two strain components is constant and negative the fatigue patterns consist of two sets of parallel ridges symmetrically spaced with respect to the principal strain axes, of equal intensity and sharply defined (i.e., of small randomness). They may lie in any direction

depending on the value of the ratio of strain components. The preferential directions under these conditions approximate those in which no changes in length occur, but have been shown not to coincide with them exactly. It is therefore thought that the preferential directions are determined by the lines of zero elongation to a first approximation and are subject, in addition, to a secondary effect the nature of which has not yet been determined.

When the ratio of the two strain components is not constant during the straining process (e.g., when there is a phase lag between the two components of vibration) the resultant fatigue patterns appear to be the superimposed effects of instantaneous ratios of strain components, and the preferential directions of the ridges are generally more randomly distributed.

The results obtained contradict the assumption that failure occurs along the directions of maximum shear and suggests that the critical directions are determined by extrema in the strain distribution. The described experiments are only early steps in a novel approach to the problem of fatigue and failure. To what extent conclusions drawn from the observation of powders may be generalized cannot be stated at this stage. When other materials are investigated attention should also be paid to the influence of phase differences whose randomizing effect may possibly be utilized in retarding the process of failure. It is hoped that further development will widely extend the range of materials that can be tested on a flexible bounding member and that the method will become an accepted supplement to other mechanical tests.

VOL.
1
1958

References

1. Weissenberg K., *Bull. Brit. Soc. Rheol.*, 1955, No. 43, 6.
2. Jobling A. and Roberts J. E., *Rheology*, Part 2, edited by F. R. Eirich. Academic Press, New York, 1957.
3. Jobling A. and Roberts J. E., *Brit. J. Appl. Phys.*, 1958, **9**, 235.
4. Grossman P. U. A., *J. Sci. Instrum.*, 1958, **35**, 131.

Fatigue of bituminous road mixes

By R. N. J. Saal (Amsterdam) and P. S. Pell (The University, Nottingham)

There is some evidence that the cracking of bituminous road carpets may be due to fatigue failure. To determine the fatigue characteristics of bitumen-mineral aggregate mixtures, tests have been carried out on rotating point loaded cylindrical cantilever specimens, and also on "necked" cantilever specimens subjected to pure bending. These tests at varying alternating stress levels, at different temperatures and speeds, showed that the material exhibits fatigue properties over wide stress ranges, and that for a particular temperature and speed of loading, the log stress–log number of cycles to fracture relationship is linear between 10^4 and 10^8 cycles.

Life is critically dependent on the temperature of the test, a low temperature giving a longer life at a particular stress level. For example a change in temperature of 20°C results in a difference in life of approximately 100 times. But taking into account the stiffness of the material which depends on temperature, speed of loading, rheological characteristics, and composition of the mix, it has been found that when the logarithm of the strain $\left(\frac{\text{nominal stress}}{\text{stiffness}}\right)$ is plotted against the logarithm of the number of cycles, all the experimental results at different speeds and temperatures for one mix lie, with a certain amount of scatter, about a straight line. It appears therefore that the factor effecting the fatigue life of a particular bitumen-aggregate mixture is one of strain rather than stress, and the effects of temperature and speed of loading can be accounted for by their effect on the stiffness of the specimen.

Similar results have been obtained for mixes containing different volume concentrations of aggregate, but as the quantity of aggregate in the mix is reduced, so the life for a given strain increases.

Tests have shown that the surface condition of the specimen has little effect, but an increase in the overall void content can reduce the life considerably. The effects of rest periods and of recompaction at intervals during the fatigue life have been investigated, and show that rest periods even at higher temperatures appear to have no significant effect. Further, work on the effect of mean stress superimposed on the alternating stress has been carried out.

Fatigue tests have also been performed in a constant strain machine, and showed that the stress during a test at a particular strain remains sensibly constant. Specimens tested in fatigue at a constant torsional oscillating strain confirmed the earlier findings that the life was dependent on the strain only and not on the temperature.

The development of micro-cracks in concrete

By R. Jones (Road Research Laboratory, Department of Scientific and Industrial Research)

The paper presents the evidence which has shown that microcracks occur in concrete specimens prior to failure and considers the influence of the propagation of these cracks on the ultimate failure of the concrete.

The detection of microcracks can be made by the following methods :—

(1) Microscopic examination of the exposed faces of the concrete specimens.

(2) Measurement of the strain distribution along one of the exposed faces of a specimen.

(3) Measurement of the change in the transit time of an ultrasonic pulse as it passes through the concrete between two opposite faces of a specimen.

Microscopic examination is tedious and does not necessarily reveal cracks in the initial stages of development. Measurement of the strain distribution has been used chiefly on the tension face of a beam in flexure where the development of a crack leads to an excessive local tensile strain : this technique has been considerably improved by using wire resistance strain gauges in place of extensometers. The ultrasonic pulse measurement enables the presence of cracks to be determined from the increase which occurs in the transit time of the pulse : it has been used chiefly on specimens tested in compression.

Microcracks have been found to develop in concrete specimens being tested in compression at 30 to 70 per cent of the failing load depending upon the test conditions ; the load at which such cracks begin to occur depends upon the shape of the specimen and the composition of the concrete. The cracks are orientated parallel to the direction of application of the load and are due to the rupture of the weakest bonds within the concrete under the action of local tensile or shear stresses which develop at the interfaces between the cement paste and aggregate. The mode of failure of a specimen tested in compression is influenced by the frictional restraint imposed over its ends by the platens of the testing machine. Under normal test conditions there is appreciable end restraint which causes lateral stresses to be developed over the ends of the test specimen. The distribution of the lateral stress is such as to prevent the cracks from forming within zones (pyramidal in cubes, conical in cylinders) at each end of the test specimen. In the cracked regions of the specimen, further damage ensues as the external load increases but the specimen continues to sustain the load by virtue of the internal friction of the aggregate. Final failure occurs when the frictional forces are overcome and the crack-free end zones are forced into the damaged concrete.

In the normal flexural test, when the load is increased continuously cracks have been detected on the tension face of concrete beams at 60–70 per cent of the failing load. Again, the initial cracks occur when there is a rupture of the weakest bonds in the concrete and there is evidence to show that the strain at which this occurs is the same as the lateral strain at which initial cracks are formed in specimens of the same concrete in compression. There are several aspects of final failure in flexure which are, as yet, unexplained, i.e., the effect on the flexural strength of changes in rate of loading and anomalous changes in the flexural strength due to changes in the percentage of coarse aggregate. These could probably be explained if there was a better knowledge of the mode of propagation of the microcracks in the concrete.

VOL.
1
1958

Rupture of rubber

By A. G. Thomas (British Rubber Producers' Research Association)

Previous publications[1, 2] have described a theory to correlate the tear behaviour of differently shaped tear test pieces of vulcanized rubber, and experiments, using natural rubber, which tended to confirm it. The

basic parameter of this theory is the " tearing energy " which is assumed to be a constant of the material, independent of the shape of the specimen. A more searching test of the theory has now been made by experiments on three test pieces of widely different shapes. Two of these test pieces, the " simple extension " and " pure shear " types, have been described previously[1], whereas the third is novel. All of them have a calculable behaviour in that the tearing energy can be derived directly from the tearing forces, strains and the test piece dimensions. The rubber used was a gum GR-S compound, which is a convenient experimental material for this purpose. The results show that the tear behaviour of the test pieces can be quantitatively related to each other by means of the tearing energy concept, and confirm the theory within the limits set by the reproducibility of the tear process.

OL.
1
958

This rupture concept has been used to interpret measurements on cut growth in natural rubber gum vulcanizates. If a test piece of one of these materials containing a cut is repeatedly strained and relaxed the cut grows, although the maximum applied load may be such as to cause virtually no continuous growth if it was applied statically. This is unlike the behaviour of a non-crystallizing polymer, such as GR-S, which exhibits steady cut growth under a static load. Observation of the tip of a cut in a natural rubber test piece while it is being stretched shows that some tearing is taking place at loads much smaller than that required to produce large scale, " catastrophic ", tearing. This cut growth ceases as soon as the load stops increasing, and it is possible to estimate its amount from measurements on the torn rubber at the tip. Using one of the test pieces mentioned above (the " simple extension " test piece), the tearing energy T can be found from the applied force, and so the relation between T and the amount of cut growth ΔC can be found experimentally. The empirical relation $T^2 = G_s.\Delta C$ is found to represent the results adequately, where G_s is a constant. This type of tearing is termed " static " cut growth to distinguish it from that occurring under repeated loading (" dynamic " cut growth).

With repeated loading the cut growth is found to decrease in rate to a final steady value, this being associated with a progressive roughening of the initially smooth razor cut tip. An analogous relation to that for " static " cut growth is found between the maximum T attained and the amount of cut growth per cycle ΔC, viz., $T^2 = G_d.\Delta C$.

Experiments have been done to confirm that the tearing energy concept is valid for " dynamic " cut growth by comparing the cut growth rates for the " simple extension " and " pure shear " test pieces. The results are consistent with the theory.

References

1. Rivlin R. S. and Thomas A. G., *J. Polym. Sci.*, 1953, **10**, 291.

2. Thomas A. G., *J. Polym. Sci.*, 1955, **18**, 177.

Torsional fatigue of fibres

By A. K. VAN DER VEGT (T.N.O., Delft)

The fatigue behaviour of single fibres has been studied by subjecting them to repeated torsional deformations. The apparatus used enables the simultaneous testing of one hundred fibres. The test fibres have a length of 10 mm and are straightened by an adjustable longitudinal tension ; the amplitude of torsional deformation can be varied within a wide range. From the amount of torsion, the fibre length and the fibre diameter, the shear strain, γ, can easily be calculated.

Numbers of cycles to failure are recorded for each individual fibre. When the percentage of broken fibres is plotted against the log of the number of completed cycles, the cumulative statistical distribution of fatigue life is obtained, i.e. the probability that a fibre will not survive a certain number of cycles. This distribution, which extends over a few decades, may in the first instance be characterized by its median, $N_{0.5}$, denoting the number of cycles after which 50 of the 100 fibres are broken.

The fatigue test has, for each sample, been performed at several strain levels ; the results permit the construction of curves relating shear strain amplitude, γ, to median fatigue life, $N_{0.5}$. These characteristics were determined for nylon, dacron, orlon, acetate rayon and viscose rayon. Obviously the position of the fatigue curve is, for each fibre, partly determined by its limiting torsional strain, γ_B, which is the strain reached in a single cycle leading to instantaneous failure. In order to eliminate this influence, curves have been constructed relating γ/γ_B to $N_{0.5}$, so as to give a better basis for comparison of the real fatigue behaviour. From these curves it can be seen that nylon has the highest fatigue resistance and viscose rayon the lowest ; the ratio between the median fatigue lives of these fibres amounts to 500.

The general shape of the strain-life characteristics is rather unusual ; it gives no indication of an endurance limit for any of the fibres. The curves first tend to level off but they bend downward rather suddenly. This shape is the most pronounced for the dacron curve ; here it appears to be a consequence of the fact that the differential distributions of fatigue lives have two maxima, i.e. the numbers of cycles to failure form two separate groups. For large strain amplitudes practically all data are in the first (short time) group ; for small strains only the second (long time) group is present. Between these extremes, variation of strain causes a gradual growth of one group at the expense of the other. It is possible to separate the two parts of the distribution graphically and to determine for each the median as a function of strain.

Obviously the existence of the two maxima suggests that there are two different mechanisms of failure. The morphology of broken fibres appears, indeed, to be entirely different for the two groups. Fibres broken in rather short times, i.e. by a high strain amplitude, show a smooth fracture ; those in the second group, however, appear to have suffered a gradual disintegration, finally resulting in rupture.

VOL.
1
1958

The other fibres investigated show a more or less similar behaviour, though the transition between the two mechanisms of failure is a more gradual one.

High-temperature creep fracture in metals

By P. Feltham and J. D. Meakin (The University, Leeds)

Isothermal creep of oxygen-free high-conductivity copper (99·99%) was studied in the range 400—700°C *in vacuo*. The equilibrium or second-stage strain rate $\dot{\epsilon}(\sigma,T)$, which is a function of the applied constant tensile stress σ and the temperature, was found to be related to the time to fracture by the law $\dot{\epsilon}/t_f = C$, where C is a temperature and stress independent constant having the dimensions of strain. This relationship held over the entire range of strain rates used, i.e. 10^{-6}–10^{-3}-sec^{-1}, and appears to be consistent with the assumption that fracture results as a consequence of the growth of voids by the absorption of vacancies formed during creep; the voids seem to nucleate heterogeneously at grain boundaries. Creep data on brasses and other metals confirm the generality of a law of the form $(\dot{\epsilon}/t_f)^m = C$ with m frequently close to 1. This relation is useful for abridging creep tests, and may well find application with non-metallic materials as well.

The sensitivity of microcreep to fatigue damage in metals

By A. J. Kennedy (College of Aeronautics, Cranfield, Bucks.)

Fatigue stresses are known to promote either hardening or softening processes in metals, depending on the initial state and the stressing conditions, such changes having been detected by hardness and creep-rate measurements. The present experiments were prompted by these observations and were so designed that the metal test-piece could be subjected to small amounts of torsional microcreep during the course of longitudinal fatigue stressing. Both lead and aluminium have been tested under these conditions, and in both cases, although the total creep strain is small, the activation energy for the process is found to be the same as that for macrocreep, so it may be presumed that the creep is in both cases controlled by the same mechanism, namely self-diffusion.

For test pieces which are initially fully annealed, the torsional creep strain amplitude under forward and reversed stresses (applied for fixed times) at first decreases, that is, the material hardens, and then increases, at about 75% of the fatigue life, up to the final failure. This dependence of the microcreep on the development of fatigue is found to be more sensitive if the creep tests are conducted with the fatigue stress (which is longitudinal) still imposed. The changes brought about by the fatigue stressing cannot be annealed out by a thermal treatment.

Another feature of these experiments is that the strain recovery, when the creep stress is removed, after some period of torsional creep is greatly accelerated by the application of the fatigue stress : indeed, complete strain recovery may not occur even after extended times in the absence of fatigue.

The theoretical implications of these results are discussed particularly in relation to dislocations and point defects.

The geometry of the plastic deformation of the polycrystalline aggregate

By T. Ll. Richards (Imperial Chemical Industries Ltd., Metals Division, Birmingham)

VOL.
1
1958

A geometric analysis of the tensile deformation of cube-texture copper strip has been carried out as part of an investigation, the broad outline of which was to define the plastic behaviour of a polycrystalline aggregate over the whole plastic range of the material in terms of its physical properties and crystal structure. The high degree of preferred orientation of cube-texture copper strip, (100) plane parallel with the strip surface and [001] direction parallel with that of the rolling, facilitates the geometric analysis of tensile test results, yet the misorientation between neighbouring crystals gives rise to interaction at crystal boundaries so that the material must be regarded as a polycrystalline aggregate rather than as a single crystal. Furthermore, grain interaction ensures that each crystal is deformed essentially as the macroscopic strain of the specimen as a whole.

The geometric analysis is therefore carried out as if the strain were homogeneous and it is noted that the extension in [011] at maximum load which represents the true limit of uniform elongation and associated lattice rotation corresponds to co-operative double slip in $[\bar{1}01]$ or $[\bar{1}10]$ on alternate (111) planes or on the symmetrical system associated with $(\bar{1}11)$ planes. [011] extension is thus equivalent to a simple shear on $[\bar{2}11]$ (111) which is accompanied by a change in specimen thickness but none in width.

For extension in [001] the tension axis is symmetrical to all four available {111} planes and to two directions in each plane. Equal amount of shear is possible on each of the eight systems and the fact that extension in [001] is not accompanied by any lattice rotation and that the limit of uniform elongation is 1/6th indicates that deformation occurs by equal and co-operative multiple shears on all available symmetrical systems. The strain which could, for example, be accomplished by unit slip on every third plane of one or other of the available {111} planes is therefore equivalent in net effect to a pure extension in [001].

By apportioning the total strain in any direction between two components, of [001] and [011] extension, it has been possible to predict the limit of uniform elongation and associated lattice rotation and account for the plastic anisotropy of cube-texture material.

Work hardening is a function of lattice orientation but since the stress for a given strain is smaller for extension in [011] than for one in [001] the relationship does not correspond to the constant resolved shear stress criterion of single crystal slip. Since shears are vectorially additive then co-operative shears are less than their arithmetic sum and it is shown that variation of stress for a given strain with direction of testing is consistent with the concept that extension in [100], [012] and [011] are accomplished by independent slip movements, co-operative treble or double slip respectively while stresses for extensions in intermediate directions correspond to appropriate combinations of these shears.

The yield criterion over the whole plastic range is one of limiting shear energy on particular crystallographic shear systems. For extension in directions near [001], which resembles simple extension, the limiting shear energy on the most favoured slip systems is approximately three times that for an equal strain in other extension directions when the analysis indicates that the deformation takes place by simple shear processes. The variation of the elastic energy–strain relation, of the fracture energy and of the stress–strain relation with direction can all be determined from purely geometric considerations.

A possible physical model is considered in relation to current dislocation theory, in which it is assumed that work hardening is associated with the development of dislocation networks of progressively decreasing cell size. Plastic deformation occurs when the elastic energy of the specimen is sufficient to initiate movement of all dislocations in the network.

Although the analysis relates specifically to the plastic behaviour of cube-texture copper, the consistency of the results of treatment of all the various aspects confirms the usefulness and validity of the geometric approach. Extension of the treatment to the random polycrystalline aggregate should be possible, as well as to any metal, single phase or multiphase alloys provided the elastic constants of the single crystal components are known. Such treatment would undoubtedly throw considerable light on the mechanical behaviour of metallic materials under specific conditions, either simple uniaxial tension as in the present instance, or the more complex conditions, as in creep or fatigue.

Fracture as the limit of flow

By A. GRAHAM (National Gas Turbine Establishment, Farnborough)

A recently completed quantitative study of the creep to rupture of Ni–Cr alloys of Nimonic type, to be described in detail elsewhere, has provided evidence of the circumstances of flow in which fracture may occur.

In order critically to test previous conclusions on constant stress creep—as being probably the simplest case of flow—careful creep experiments have been done by G. J. BATES and creep data of high quality has

been analysed by K. F. A. WALLES. It had previously been found that the decelerating stages of the creep of these alloys were well represented by effectively the first three terms of the Andrade formula. These involve the well established powers $\frac{1}{3}$ and 1 of time t. It was then found that the accelerating stage of creep required the inclusion of a further term in t^3. The indicated formula, namely

$$\epsilon = \epsilon_c + \left(\frac{t}{t_{\frac{1}{3}}}\right)^{\frac{1}{3}} + \left(\frac{t}{t_1}\right) + \left(\frac{t}{t_3}\right)^3,$$

in which ϵ is the estimated strain, ϵ_c a correction for incorrect estimation of the strain that occurs during loading, and $t_{\frac{1}{3}}$, t_1, and t_3 are constants, was closely confirmed by the experiments. Experimental sources of error were believed near a minimum ; also the residual errors, the errors of reduction of readings, the corrections necessary for the loading stage, and the inherent scatter of the material, were all quantitatively assessed. The results and those from the analysis of creep data were in agreement.

The result of present concern is that the creep curves just prior to rupture showed only barely-significant signs of the imminence of rupture. For one batch of material the specimens ruptured after all three terms of the formula had reached observable values, and for another, rupture occurred before the final term became appreciable. In the latter circumstances the material effectively obeyed the Andrade formula.

For either batch, only the final experimental point, apart from exceptions considered below, could perhaps be regarded as falling outside the scatter from the theoretical curve. In most instances it fell at a slightly higher strain than expected ; in others there was no observable departure, and in a few there was an equally slight fall.

An explanation of points falling high was provided by two experiments with this result from which the specimens, of the first batch, were removed before rupture occurred. The specimens had surface cracks. Also the cracking of one appeared to have been initiated at a time when a sudden bending was recorded. Up to this time there was no observable departure from the formula. Another specimen from the same batch that was expected from its history to be near rupture but on which no surface cracks were observable was found on sectioning to have internal cracks. At least one crack had an end lying at a junction between three grains. For this specimen there was again no observable departure from the formula.

For one specimen, the points had a definite trend towards lower strains prior to rupture. The creep curve appeared to be of an " anomalous " type that is known for a number of materials and is the subject of a separate investigation.

These results, which are generally consistent with the fall of points about families of creep curves for alloys of the type considered, clearly indicate that trends towards larger strains just prior to rupture are due

VOL.
1
1958

to the formation of cracks and that, at the instant of initiation of cracking, the trend, whether towards larger or smaller strains is, the last result apart, extremely small.

The alternative conclusions are either that rupture is determined by a condition, like that of cohesive strength, which bears no relation to the amount of flow that has occurred, or that deformation proceeds closely according to the formula until the terms reach limiting values. The latter appears more likely because the scatter in creep over a range of stress and temperature for these materials, when assessed in terms of a now well-supported formula of which the above is a special case, was found to be in close quantitative agreement, material by material, with the scatter in their creep rupture data. The agreement involves that rupture is determined by a constant-strain type of condition.

OL.
1
958

EDITED PROCEEDINGS OF THE

SECOND INTERNATIONAL CONFERENCE ON THE PEACEFUL USES OF ATOMIC ENERGY, GENEVA,

SEPTEMBER 1958

Editorial Advisory Group :
D. I. BLOKHINTSEV
J. V. DUNWORTH
D. J. HUGHES
I. I. NOVIKOV
F. PERRIN
A. M. WEINBERG

PERGAMON PRESS is pleased to announce that the Board of Editors of Progress in Nuclear Energy, the International Review Series in Atomic Energy, have made arrangements to publish the Edited Proceedings of the Second International Conference on the Peaceful Uses of Atomic Energy in twelve separate volumes, similar to those edited by them and published by Pergamon Press on the First International Conference on the Peaceful Uses of Atomic Energy held in Geneva in 1955.

All volumes will be published and distributed between December 1958 *and April* 1959. *In order to ensure receipt of copies immediately upon publication, please place your order now.*

Customers who have already a standing order for the Progress in Nuclear Energy Series will automatically receive the appropriate volumes.

Price :—

Single volumes £5 5s. 0d. net ($15.00)

Complete set of 12 volumes
£63 net ($180.00)

An 8-page brochure, describing in full detail the Edited Proceedings, is available free, on request. Please write to :

PERGAMON PRESS
4 & 5 Fitzroy Square, London W.1

VOL.
1
1958

OL.
1
958